LIST OF MEMBERS

of

NATIONAL PLANNING COMMITTEE

(Including Representatives of Governments)

JAWAHARLAL NEHRU (Chairman)

Sir M. Visveswaraya, (Resigned)	J. C. Kumarappa, (Resigned)
Sir Purshottamdas Thakurdas	Walchand Hirachand
Dr. Megh Nad Saha	Dr. Radha Kamal Mukerjee
A. D. Shroff	Prof. J. C. Ghosh,
A. K. Shaha	Hon'ble Mr. Shuaib Qureshi
Dr. Nazir Ahmad	Rani Laxmibai Rajwade
Dr. V. S. Dubey	Abdur Rahman Siddiqui
Ambalal Sarabhai	Gulzarilal Nanda
N. M. Joshi	Mrs. Vijayalakshmi Pandit

K. T. Shah, (Hon. Gen. Sec.)

Members

Hon. Mr. V. V. Giri, Minister for Industries, Madras

Hon. Mr. L. M. Patil, Minister for Industries, Bombay

Hon. Dr. Syed Mahmud, Minister for Education and Development, Bihar

Hon. Mr. C. J. Bharuka, Minister for Industries, Central Provinces

Director of Industries, Bombay

Director of Industries, Bihar

Director of Industries, Assam

Minister in Charge of Industries, Bhopal

Director of Industries, Hyderabad, Dn.

Director of Industries, Mysore

Development Commissioner, Baroda

Director of Industries, Baroda

RIVER TRAINING AND IRRIGATION

NATIONAL PLANNING COMMITTEE SERIES

Rural Marketing and Finance

River Training and Irrigation

Soil Conservation and Afforestation

Land Policy, Agricultural Labour and Insurance

Animal Husbandry and Dairying, Horticulture and Fisheries

Crops—Planning and Production

Rural and Cottage Industries

Power and Fuel

Chemical Industries

Mining and Metallurgical Industries

Manufacturing Industries

Industries connected with Scientific Instruments and Engineering Industries

Labour

Population

Trade—(Internal and Foreign)

Public and Industrial Finance

Currency, Exchange and Banking

Insurance (Individual and Social)

Transport (Road, Rail, Air and Water)

Communications (Posts, Telegraphs, Telephones and Radio)

National Housing

Public Health

Education—General and Technical

Woman's Role in Planned Economy

NATIONAL PLANNING, PRINCIPLES & ADMINISTRATION

K. T. Shah.

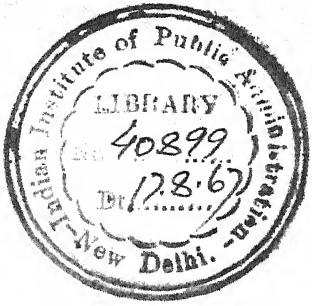
NATIONAL PLANNING COMMITTEE SERIES
(REPORT OF SUB-COMMITTEE)

RIVER TRAINING
AND
IRRIGATION

Chairman
Nawab Ali Nawaz Jung Bahadur

Secretary
Mr. U. N. Mahida, I.S.E.

Edited by
K. T. SHAH
Honorary General Secretary
NATIONAL PLANNING COMMITTEE



VORA & CO., PUBLISHERS LTD.
3, ROUND BUILDING, KALBADEVI ROAD, BOMBAY 2.

First Edition, December, 1947

Price Rs. 6/- only

To
All Those
MEMBERS OF THE NATIONAL PLANNING COMMITTEE
and of
Its Various Sub-Committees
A TRIBUTE OF APPRECIATION

प्रारब्धमुत्तमजना न परित्यजन्ति

PERSONNEL OF THE SUB-COMMITTEE ON RIVER TRAINING AND IRRIGATION

Chairman

NAWAB ALI NAWAZ JUNG BAHADUR

Secretary

Mr. U. N. MAHIDA

Members

Dr. Megh Nad Saha

Dewan Bahadur V. G. Shete

Representatives of Governments

Shri Moti Ram, I.S.E., (U.P.)

Shri G. D. Agarwal, I.S.E., (C.P.)

Mr. Ali Ahmed, B.A., (Assam)

Shri S. C. Majumdar, (Bengal)

Shri G. Seshagiri Rao, L.C.E., (Mysore)

PREFACE

The National Planning Committee, appointed in 1938, began its work early in 1939. After defining the nature of a National Plan, and determining the nature and scope of the work entrusted to them, the Committee issued an elaborate and comprehensive Questionnaire which was subsequently supplemented by specific details. Twenty-nine Sub-Committees, formed into eight groups, were set up with special terms of reference to deal with all parts and aspects of the national life and work in accordance with a predetermined Plan.

After some unavoidable delay in getting replies to the Questionnaire, the Sub-Committees began their work, and submitted Reports,—some of them Final, some Interim,—which were considered at the Plenary Sessions of the Parent Committee in 1940. Towards the end of that year the Chairman, Pandit Jawaharlal Nehru, was arrested and sentenced to a long term of imprisonment, during which the work of the Committee had necessarily to be suspended.

On his release a year later, hope revived for an intensive resumption of the Committee's work. But the outbreak of war with Japan, the threat to India's own safety, and the hectic march of political events, rendered it impossible to devote any attention to such work at that time. It, therefore, inevitably went into cold storage once again; and remained for the duration of the war.

When at last the War seemed nearing its end, Pandit Jawaharlal Nehru with other leaders was released. The moment seemed again opportune to resume the work of

the Planning Committee. Meetings of that Body were held in September and November 1945, when certain more urgent questions, already included in the programme of the National Planning Committee, were given a special precedence. A Priority Committee was appointed to report upon them. Changes and developments occurring during the War had also to be taken into account; and another Committee was appointed to review the general instructions, given six years earlier to the Sub-Committees. Revised instructions were issued to them following the Report of this Sub-Committee; and the Chairmen and Secretaries of the several Sub-Committees were once again requested to revise and bring up to date such of the Reports as had already been submitted—either as final or interim—while those that had not submitted any reports at all were asked to do so at an early date.

As a result, many of the Sub-Committees which had not reported, or had made only an Interim Report, put in their Reports, or finalised them. The Parent Committee has had no chance to review them, and pass resolutions on the same. But the documents are, by themselves, of sufficient value, prepared as they are by experts in each case, to be included in this Series.

The following Table shows the condition of the Sub-Committees' work, and the stage to which the Planning Committee had reached in connection with them.

Serial No.	Name of the Sub-Committee.	Final Report		Interim Report		No Reports
		N.P.C. Resolutions	Not considered by N.P.C.	N. P. C. Resolution	Not considered by the N.P.C.	
Group I.	**Agriculture & other Sources of Primary Production**	Handbook Pp.		Handbook Pp.		
1.	Rural Marketing and Finance	97-99				
2.	River Training and Irrigation Part I	83-85				
	,, ,, ,, Part II	113-115				
3.	Soil Conservation and Afforestation	115-119				
4.	Land Policy and Agriculture			139-141		
5.	Animal Husbandry and Dairying	87-89				
6.	Crop Planning and Production				do.	do.
7.	Horticulture	102-103				
8.	Fisheries					
Group II	**Industries or Secondary Sources of Production**					
1.	Rural and Cottage Industries					
2.	Power and Fuel		do.			
3.	Chemicals					do.
4.	Mining and Metallurgy			77-79		
5.	Engineering Industries	75-77		130-133		
6.	Manufacturing Industries		do.			
7.	Industries connected with Scientific Instruments		do.			
Group III	**Human Factor**					
1.	Labour	89-92				
2.	Population	85-87				
Group IV	**Exchange and Finance**					
1.	Trade					
2.	Public Finance					
3.	Currency and Banking			122-126		
4.	Insurance			93-95		
Group V	**Public Utilities**			95-97		
1.	Transport					
2.	Communications	126-129		120-122		
Group VI	**Social Services-Health and Housing**					
1.	National Housing					
Group VII	**Education**					
1.	General Education			133-139		
2.	Technical Education				do.	
Group VIII	**Woman's Role in Planned Economy**					

To sum up, fourteen Sub-Committees had made final reports, of which ten have been considered, and Resolutions taken upon them, by the National Planning Committee. Twelve more have presented Interim Reports, of which nine have been considered by the Planning Committee, with Resolutions thereon, while three Sub-Committees have not yet presented any report on the reference made to them.

The idea that all this material, gathered together with the help of some of the best brains in India in the several departments of our national life, should be printed and published was before the Committee from the start. But the interruption caused by the war prevented its realisation. It was once again mooted in 1941; but the moment was not deemed ripe then for such action, partly because the leading spirits in almost every one of the Sub-Committees were unable to devote time and labour to bring their Reports up-to-date; and partly also because war-time restrictions or shortages had made scarcer than ever before the statistics and other facts, which particular sub-committees would need, to bring their work up-to-date. The War time needs of Government had attracted several of them to work on Government Bodies, Panels, or Committees. For all these reasons it was deemed undesirable that material of this character—valuable as it must be—should be put out in an incomplete, inchoate, obsolete form, which may reflect unfavourably upon Indian capacity for such tasks.

The last four years of the War were thus a period of suspended animation for the National Planning Committee. Even after the end of the war, it has not been feasible, for obvious reasons, for the Planning Committee to resume its work and finalise decisions. Continuous sessions of that body are indispensable for considering and taking decisions on the Sub-Committee reports presented since 1940, and putting all the material into shape, ready for publication, not to mention making its own Report; but the political situation in the country made it impossible. Other conditions, however, are somewhat more favourable than in 1938-39, when the Central Government of the country were all but openly hostile to such attempts. Lest, however, the momentary difficulties make for needless further delay, it was thought advisable by the Chairman and the undersigned that no more time should be lost in putting this material before the Public. Following this advice, it is now proposed to bring out a complete Series of the National Planning Committee's Sub-Committee Reports, which will

serve as appendices to the Parent Committee's own Report. The Plan of the proposed enterprise is briefly summarised below.

Every Sub-Committee's Report, which is in a final form and on which the National Planning Committee has itself taken resolutions, will be edited and published, with an Introduction assigning their due importance to the suggestions and recommendations contained in that particular report, its proper place in the over-all National Plan; and following it up, wherever necessary, by a kind of Epilogue, summarising the developments that have taken place during the seven years, during which the work of the Planning Committee had been in suspension.

Those Reports, again, which, though in a final form, have not yet been considered, and no resolutions taken thereon, by the Planning Committee, will also be included in the Series in the form in which they were submitted, with such Introduction and Epilogue to each as may be deemed appropriate. And the same treatment will be applied to Reports which are 'Ad Interim', whether or not the Parent Committee has expressed any opinion on the same. They will be finalised, wherever possible, in the office, with such aid as the Chairman or Secretary of the Sub-Committee may be good enough to render. Sub-Committees finally, which have not submitted any Report at all, —they are very few,—will also find their work similarly dealt with. The essence, in fine, of the scheme is that no avoidable delay will now be suffered to keep the National Planning Committee's work from the public.

Both the Introduction and the Epilogue will be supplied by the undersigned, who would naturally be grateful for such help as he may receive from the personnel of each Sub-Committee concerned. The purpose of these additions is, as already stated, to assign its true place to each such work in the overall Plan; and to bring up the material in each Report to date, wherever possible.

Not every Sub-Committee's Report is sufficiently large to make, more or less, a volume by itself, of uniform size, for this Series. In such cases two or more Reports will be combined, so as to maintain uniformity of size, get-up, and presentation of the material. The various Reports, it may be added, would not be taken in the order of the classification or grouping originally given by the Planning Commit-

tee; nor even of what may be called the intrinsic importance of each subject.

In view of the varying stages at which the several Reports are, for reasons of convenience, it has been thought advisable to take up for printing first those which are final, and on which the Planning Committee has pronounced some resolutions. Printing arrangements have been made with more than one Press, so that two or three Reports may be taken simultaneously and published as soon as possible so that the entire Series may be completed in the course of the year.

Two other Sub-Committees, not included in the list of Sub-Committees given above, were assigned special tasks of (1) preparing the basic ideas of National Planning; and (2) outlining the administrative machinery deemed appropriate for carrying out the Plan. These were unable to function for reasons already explained. The present writer has, however, in his personal capacity, and entirely on his own responsibility, published the "Principles of Planning" which attempt to outline the fundamental aims and ideals of a National Plan. This remains to be considered by the Planning Committee. Similarly, he has also attempted to sketch an administrative machinery and arrangements necessary to give effect to the Plan, when at last it is formulated, and put into execution. Notwithstanding that these two are outside the Scheme outlined in this Preface, they are mentioned to round up the general picture of the arrangements made for publication of the entire work up-to-date of the National Planning Committee and its several Sub-Committees.

The several volumes of Sub-Committee Reports, when published, will be treated as so many appendices to the Report of the parent body, the National Planning Committee. It is impossible to say when that Committee, as a whole, will be able to hold continuous sessions, review and resolve upon Sub-Committee Reports which have not yet been considered, and lay down their basic ideas and governing principles for an all over Plan, applicable to the country, including all the facts of its life, and all items making up the welfare of its people.

The disturbed conditions all over the country, and the Labour unrest that has followed the end of the War has caused unavoidable delays in printing and publishing the

several volumes in the Series, which, it is hoped, will be excused.

In the end, a word of acknowledgment is necessary to put on record the aid received by the Editor in the preparation and publication of this Series. All those who are associated in the task,—members of the Parent Committee, or as Chairmen, Secretaries or Members of the various Sub-Committees,—have laboured wholly, honorarily, and consistently striven to give the best that lay in them for the service of the country. Almost all Provincial Governments and some States,—the latter twice in some cases,—have made contributions towards the expenses of this office, which have been acknowledged and accounted for in the Handbooks of the Planning Committee, published earlier. Suitable appreciation of these will be expressed when the Parent Committee makes its own Report. At almost the end of its task, the expenditure needed to edit, compile, and otherwise prepare for the Press, the several Reports, has been financed by a Loan by Messrs. Tata Sons Ltd., which, even when repaid, will not diminish the value of the timely aid, nor the sense of gratitude felt by the undersigned.

Bombay,
1st July, 1947.

K. T. Shah

CONTENTS

		Page
Preface	K. T. Shah	9
Introduction	K. T. Shah	17
REPORT:		
Part I. Irrigation in India: Nawab Ali Nawaz Jung Bahadur		30
Part II. River Training and Protection against Floods: Nawab Ali Nawaz Jung Bahadur		55
Part III. Water Power Exploitation: Nawab Ali Nawaz Jung Bahadur ..		69
Note on the Functions of the Irrigation Branch, P.W.D., U.P.		94
Appendix A: Statements 1 to 5		99
Part IV. Future of Waterways:	G. L. Mehta	105
Resolutions passed by the N.P.C. on the Report ..		111
Questionnaire issued by the N.P.C.		117
Summary of Developments.....	K. T. Shah	119
Outline of Proposed Legislation Damodar Valley Authority		131
Electricity: Rationalisation of the Production and Distribution		133-143

INTRODUCTION
To
The Report of
IRRIGATION & RIVER TRAINING SUB-COMMITTEE

This Sub-Committee was given the following Terms of Reference :—

(a) the care of rivers (including river sanitation and water supply for human consumption) ;

(b) training of rivers for development of power;

(c) protection against floods ;

(d) utilisation of rivers for navigation ;

(e) providing adequate water for agriculture, by canal, well or tank irrigation ; and any other questions connected with water supply and conservation.

This Reference makes the work of this Sub-Committee closely connected with that of the Sub-Committees on Crop Planning and Production, Power & Fuel, Land Revenue and Tenure, as well as Transport and Communications. Of these the Crop Planning and Production Sub-Committee has made no Report ; but others have presented some Reports wherein there would inevitably be a certain degree of overlapping in the general consideration of the problems as well as in their recommendations. These will be indicated wherever deemed necessary.

The Report of this Sub-Committee deals mainly with the problem of irrigation of land, which constitutes perhaps the most important single item in our National Economy. Agriculture or cultivation of land provides something like 75% of the annual income of this country, and maintains four out of every five persons in the land from its produce, or by work based upon its produce. The principal industries, which are expected to take off a part of the pressure of population on land, are dependent on Agriculture for at least their raw materials. The bulk of the income of the Transport Services is derived also from Agriculture, and the same may be said of other services, utilities or amenities. In the aggregate, therefore, the entire population of this country may well be said to depend upon Agriculture, directly or indirectly ; and its well-being may consequently be

well said to vary with the success of this, the most important source of producing new wealth in India.

The success, however, of Agriculture depends in a very large measure upon, *inter alia,* adequate and regular water supply. There are many reasons why the cultivation of land or crop-raising in this country is not as efficient comparatively and as productive per unit of land cultivated or labour employed as in other countries, notwithstanding certain advantages of soil and climate. Amongst these, the scarcity, uncertainty or irregularity of water supply may easily rank the highest. The main source of our water supply needed for agriculture is, of course, the annual rainfall. Thanks to the wonderful working of Nature, rains come to water the parched lands on more or less fixed dates so as to facilitate the several stages of agricultural operations and nicely dovetail them one into another. But the rainfall, though on the whole abundant, often fails, on an average once in a decade ; is generally irregular, and not evenly distributed throughout the season. In other words, the water is not available precisely as and when it is required, though in the same season it may be in excess in some parts and in deficit in others. Where it is in excess it causes heavy floods which damage the land or standing crops ; while where it is in deficit, it creates conditions of scarcity bordering upon or eventuating in a famine. In the years before the coming of the Railways and modern mechanical transport, when means of Transport and Communications were rudimentary, the dread of Famine was almost universal. Some part of the country or other was certain to suffer from it ; and so the vagaries of the Monsoon have come to be the principal factor in determining the success of Agriculture in this country.

The force and effects of these vagaries were recognised from the earliest times ; and to guard against them had become the principal preoccupation of the rulers ever since public consciousness had developed. From the earliest times it has been amongst the most sacred duties of the powers that be to construct artificial water-supply so as to make up for the deficit of rains for the raising and nourishment of crops. In the earliest times, the Village Panchayats, the Local Republics of that age, used to construct ponds or reservoirs where water could be stored up during the wet season to be used in the dry season, or if the rains failed. Where individuals held large areas of land, they sank wells thereon for the same purpose.

On a still larger scale the Central Government of each State, or of India as a whole, every time that the country became consolidated under a strong central power, constructed large-scale Irrigation Works based upon the principal Rivers and carried their waters over hundreds of miles by canals. Some of these

are even now surviving. In the latest, or the British period of our history, these Works have been constructed on a very large and wide-spread scale, though it is only about 50 years ago, after the Great Famine of 1900, that something like a comprehensive Irrigation Policy could be said to have been evolved and put into execution. The Famine & Irrigation Commissions' Reports of 1902-3 must, therefore, be read together.

Not all the Irrigation Schemes, however, recommended by the Irrigation Commission have yet been put through, though a large portion has no doubt been undertaken. Of the total net area of some 213 million acres under cultivation, about 16% is irrigated by large scale Government Works at a total cost of Rs. 156 crores in British India alone. These help to raise crops estimated to be worth twice that sum according to the "Water Ways of India" issued by the Central Board of Irrigation 1947.

Large-scale Government Works, it need hardly be added, are not the only means of such water-supply. According to official statistics, in 1940-41 :—

Government Canals irrigated		36.15 million acres
Private	„ „	3.78 „ „
Tanks	„ „	5.80 „ „
Wells	„ „	14.18 „ „
Other Sources	„ „	6.83 „ „
	Total:-	56.74 million acres.

This figure, it may be added, relates to British India only. If we add to this the Irrigation Works of all kinds in the States, the total of such facilities, according to the *Water Ways of India,* serve today some 70 million acres, "only about 12% of the culturable area in the country" (Op. cit. p.3 para 2-3).

As already stated, the water resources of the country are plentiful ; and their proper scientific development will obtain much greater service than is considered likely at present. Irrigation is, no doubt, an important purpose, for which the waters of our rivers, whether snow-fed or rain-fed, can be used ; but it is not the only one, as the Terms of Reference to this Sub-Committee show. Flowing River water can be used for developing Hydro-electrical energy, as well as for providing water for civic uses. The rivers, moreover, wherever they are perennial, may be utilised in the main channels as well as tributaries and canals for navigation purposes. If the volume of water is at any time excessive and likely to cause, —as it frequently does,—floods, we would have to provide safeguards against that danger, and its consequence in the shape of

soil erosion. The importance of all these has been recognised by the National Planning Committee, setting up separate Sub-Committees to deal with these several aspects. Thus the development of Hydro-Electrical energy is dealt with by the Power and Fuel Sub-Committee ; while the Sub-Committee on Soil Conservation deals with the problems of flood control and soil protection. The Transport and Communications Sub-Committee is expected to deal with the problems of Inland Navigation of our rivers, while the remaining uses of water are dealt with by this Sub-Committee. In this Introduction we deal mainly with irrigation.

The Irrigation Public Works are of two main kinds : Productive and Protective. Of the former, the larger proportion has both capital and revenue account, while the smaller has only revenue account. A good deal of the area thus irrigated yields double crops. The cost, both of maintenance and interest on capital is made good by special water rates, which yielded in the aggregate something like Rs. 16.36 crores in 1941-42. Against this the working expenses were Rs. 4.81 crores, so that the net return on the capital invested was calculated at 10.34%. The North Western Frontier Province led with the highest return on productive works, being 12.29%. Next came the Punjab, with 11.15%., Bombay, 8.97%, United Provinces, 7.94%; while Madras, which has a very large amount of Irrigation, yielded only 2.67%.

The charges for Irrigation Water are levied in different ways in the different Provinces. In Sind the assessment of land revenue is inclusive of water charges, which aggregate something like 9|10ths of the total assessment. In Madras and Bombay different rates of land revenue are charged according as the land is irrigated or not. The former includes the water rate. In other parts of India, the water rate is a separate charge, and adjusted to the benefit received as near as can be. The area actually irrigated is measured, and a rate is charged per acre according to the crop grown. By this means the water rate is adjusted to the service rendered. Lower rates are charged where water has to be lifted to a higher level ; while where the mere flow of water by gravitation irrigates the land the rates are somewhat higher. In some cases the outlets or channels for water are rented for a lump sum; or the charge is made according to the volume of water actually used. But these methods have proved cumbersome and unpopular. Water rates, therefore, on the whole, follow the principle of "No Crops, no Charge". The Cultivator naturally dislikes to be liable for water rates which have no connection with the area under cultivation, or the quality of the crop raised.

The rates, it may be added, vary from Province to Province. Even in the same Province they vary according to the nature of the crops. In the Punjab they vary from Rs. 7|8|- to Rs. 12|-|- per acre for sugarcane, from Rs. 4|-|- to Rs. 7|8|- per acre for

rice, from Rs. 3|4|- to Rs. 5|4|- per acre for wheat, from Rs. 3|-|- to Rs. 4|4|- for cotton and from Rs. 2|-|- to Rs. 3|-|- per acre for millets and pulses. If extra crops are grown and additional water needed, an extra charge is made for the same. Generally speaking, however, Government guarantees a sufficient water-supply for the crop which is expected to be watered, and makes it available for the period for each such crop. If the crop fails to mature, or if the yield is less than normal, either the whole or part of the irrigation assessment is remitted. In contrast with this practice, in Bengal and the Central Provinces, there is a system of long term fixed charge, whereby the cultivator pays a small rate for a term of years, whether or not he takes the water. This practice is suitable for these Provinces as the normal rainfall there is generally high, and may be depended upon for the required water supply. Artificial Irrigation is thus a kind of luxury for which the cultivator would not pay a high rate, as he would not ordinarily need extra water costing excessively in his judgment. Irrigation Works have nevertheless been constructed to guard against possible failure of rains ; and so the most acceptable method of charging seems to be to make an initially lower charge, which makes water available to the cultivator when he wants it during the terms of years for which the charge is fixed. From the view point of the cultivator, this is also economical as he need not wait till the last moment for the water he may need. And from the point of view of the Government also, it is fair, as a certain minimum charge is assured to ease the burden of interest and maintenance charges. On the whole, therefore, the charges are not excessive ; they represent a very small proportion of the extra profit earned by the cultivator.

Of the total land irrigated, large-scale Public Irrigation Works, classed as Productive, supply water to something like 26 million acres (1941-42), Protective Works irrigate 5 ¼ million acres, while Non-capital Works account for 3 ½ million acres. The largest percentage of area irrigated to the total area sown is in Sind, being 88%, with Punjab coming next highest viz: 39.56% Madras 21.18%, North West Frontier 19.08%, United Provinces 16.84%, Orissa 8.43%, Bihar 4.0%, Central Provinces 3.07%, Bombay 1.91%, Bengal 0.79%.

These figures, it need hardly be added, relate to the area irrigated by the larger Irrigation Works based upon the perennial Rivers. As has been observed in the "Water Ways of India" issued by the Central Board of Irrigation :—

> "It has been estimated, however, that so far only about six per cent of the available water wealth in the rivers of our country has been utilised. The balance runs to waste. If the utilizable, but so far unused, water potential is no more than one-third of the total, it will amount to five times the

total quantity of water which is being used at present for irrigation, throughout the country."

The total value of crops raised by the aid of Irrigation Works costing Rs. 156 crores in British India, is estimated at over Rs. 300 crores by the same authority ; and that amount can easily be increased five times, or double the present available food or raw material supplied from the cultivation of land in this country.

Irrigated Acreage :— A comparison of the acreage of crops matured during 1941-42 by means of Government irrigation systems with the total area under cultivation in the several provinces is given below :—

Provinces	Area sown in 1941-42 Acres	Area Irrigated by Govt. irrigation Works Acres	Percentage of area irrigated to total area sown	Capital cost of Govt. Irrigation & Navigation Works to end of 1941 to 42. In lakhs of rupees	Estimated value of crops raised on areas receiving State irrigation. In lakhs of rupees
Madras ...	36,419,600	7,714,700	21.18	2,041	3,306
Bombay ...	28,023,700	535,700	1.91	1,080.7	599.23
Sind ...	6,003,600	5,285,000	88.0	2,842	* *
Bengal ...	31,055,100	245,300	0.79	528.7	246.87
United Provinces ...	35,544,700	-5,986,900	16.84	@ 3,048	4.175
Punjab ...	32,299,200	=12,778,600	39.56	3,978	* *
Bihar ...	17,975,600	718,400	4.0	356	628
C. P. ...	19,897,600	609,900	3.07	652	281
Orissa ...	2,986,000	354,000	8.43	328.25	150.7
N.W.F.P. ...	2,687,000	512,700	19.08	316	309
Baluchistan..	467,900	19,300	4.11	36.25	3.57
Total ...	213,360,000	34,760,500	16.28	15,206.90	9,699.37

River Irrigation has, however, another side. The water from each river will be more or less of a similar quality, and as such may not always be suitable for the soil, the particular crops or the land through which the canals pass. The great Indus River Irrigation System, watering the till then desert areas of Sind, has revealed the handicap of salinity in the water, as the river passes through the areas of the Punjab Salt Mines. There is also the danger of *cullar,* and of the river shifting its bed as it frequently does in Bengal.

Wells and tanks, on the other hand, being on the land immediately benefitting from them, are likely to be much more suitable to the peculiarities of the soil, crop and the cultivator's ability in each case. Well Irrigation has definite advantages of its own, which make something like 30% of the total irrigated area in

this country come to be served by this means. Because the well water entails trouble on the part of the cultivator for raising it from varying depths, he is naturally careful and economical in its use, much more than when the water is brought to his door, and a charge for it made more or less compulsory. It has been estimated, again, that well water does three times as much duty as canal water. The factor of cost of lifting makes well water more generally used for high grade crops. Its pro rata burden is consequently reduced and benefit increased. It has been estimated that well-irrigated land produces at least one-third more per unit than canal-irrigated land. No doubt the latter serves in bulk large areas from a single system; and so has helped to bring what were practically desert regions under the plough, particularly in Sind and the Punjab. The canals also help to improve the chances of well irrigation, thanks to the seepage of water brought by the canal into the sub-soil where wells can be more easily sunk.

The capital cost also of constructing wells is much smaller than providing large-scale Irrigation Works, and is within the means of the average cultivator. To stimulate well construction, Government have adopted a fairly liberal policy for making advances to cultivators who want to sink wells on their land; and even foregoing the probable increase in land revenue wherever such enterprise has been shown by the cultivator. In the figures given above, it has been shown that the wells even today irrigate something like 14.18 million acres out of a total in British India of 56.75 million acres (1941-42), while tanks account for less than half that area, namely 5.8 million acres.

Next after the well in popular favour as a means of Irrigation is the Tank, which has as hoary a history as the Well. If the Well is essentially individual, the Canal is equally essentially Governmental. The Tank is local, very commonly constructed by the Village Authority. Its size varies from the large reservoirs catching and storing billions of cubic feet of water, to be used as and when required for service of thousands of acres of land adjoining, to a small store for use of the immediate village, its land and cattle.

The bulk of the cultivated land in this country is held and worked by fractionally small holders, and the ability of such cultivators is much too limited in most parts of the country to benefit fully from such artificial aids as the Great River Irrigation Works. New capital being sunk in land, wherever the Zamindar or large-scale land-holders exist, is also limited because of the immense sub-division of cultivated holdings. Co-operative Societies have tried in some Provinces to bring about some kind of consolidation of land with noticeable benefits. But until the entire land-holding system is reorganised radically, and

holdings are made much more economic for cultivation than they are today, the potentiality of our land will remain far below its normal or optimum level.

The problem of reorganising the land-holding system, with all its complexities of social, political and economic factors is much too vast to be discussed here. This much, however, may be added in rounding up the subject that, if large-scale Irrigation Works are to be the order of the day—in a properly planned economy they would appear to be the most advantageous from all points of view,—it would follow that the Land Revenue System would have to be radically recast, and along with it the charges for water and other artificial aids to Agriculture.

ADMINISRATIVE PROBLEMS

Various other problems are also connected with the nation-wide programme of Irrigation, which affect the basic policy and administrative system. Rivers, it is obvious, are not confined to only one region. They pass through several regions, Provinces and States, each of which has its legitimate claim upon the water that runs through its territory. Frequent disputes, therefore, arise between Provinces and Provinces (Sind and Punjab in regard to the Indus Water), and between Provinces and States (Mysore and Madras; Hyderabad and Madras) regarding the adjustment of the shares of Riparian Owners of the rivers. The Central Authority which, before 1937, was the sole judge in such disputes, had intervened to settle such disputes. It has evolved and employed certain principles for its guidance which have been embodied in the Government of India Act, 1935, that have not proved very satisfactory. These principles have been summarised as follows:-

(1) That the waters of a river should be utilised to the best possible advantage (for the maximum good of the maximum number) in the tracts commanded, irrespective of territorial boundaries;

(2) That it is both just and expedient that each case of dispute between Provinces or between a Province and a State should be dealt with on the merits of the individual case, and not according to previous precedents.

For instance, in regard to the dispute between the Punjab Government, the State of Bhawalpur and of Bikaner, - which was not a Riparian Owner, but yet concerned in the benefit of the Sutlej Valley Project, the Paramount Power gave its final decision according to the following formula:-

"That in considering the method of disposing of the waters made available for irrigation by the Sutlej Valley Project.

the general principle is recognised that those waters should be distributed in the best interests of the public at large, irrespective of Provincial or State Boundaries, subject always to the proviso that established rights are fully safeguarded or compensated for; and that full and prior recognition is given to the claims of Riparian Owners, and that their rights in existing supplies, or in any supplies which may hereafter be made available, in the Sutlej River below the junction of the Beas and Upper Sutlej, are fully investigated and are limited only by the economic factor" (Water Ways of India. pp 19-20).

The problem of proper utilisation of inter-statal river waters for all the many purposes which they can serve is not confined to India only. In all federally organised States, the rights of the federating Units of the same Federation to rivers flowing through more than one of them as regards the water in their own territory, have occasioned considerable difficulties; and the solution adopted by them, though not identical, has its own significance for this country.

The United States is the largest of such Federations with the most considerable water wealth. Its conditions of climate, rainfall and rivers are not dissimilar from our own. The experience of that country, particularly in the latest developments, like the Tennessee Valley Administration, is most instructive, as it makes the biggest achievement in multi-purpose utilisation of water. The inter relation between the commercial and industrial purposes, or for transport and communications; and the division of responsibility between the Federal and State Authorities, is also the closest there. Though at first the rights of the States were regarded as sacrosanct, the United States Congress has been compelled by force of circumstances to larger and larger commitments ending in the enunciation of the Federal Flood Policy in 1936. By an Act passed in that year the Congress declared a National Flood Policy, under which construction of Flood Protection Works on all navigable rivers and their tributaries may be authorised by the Congress.

The Congress recognises:—

" that destructive floods upon the rivers of the United States, upsetting orderly processes and causing loss of life and property, including the erosion of lands, and impairing and obstructing navigation, highways, railroads, and other channels of commerce between the States, constitute a menace to national welfare; that it is the sense of Congress that flood control on navigable waters or their tributaries is a proper activity of the Federal Government in cooperation with States, their political sub-divisions, and localities

thereof ; that investigations and improvements of rivers and other waterways, including watersheds thereof, for flood-control purposes are in the interest of the general welfare ; that the Federal Government should improve or participate in the improvement of navigable waters or their tributaries, including watersheds thereof, for flood-control purposes, if the benefits to whomsoever they may accrue are in excess of the estimated costs, and if the lives and social security of people are otherwise adversely affected"

The allied purposes include Irrigation as well as Navigation, Flood Control, and Hydro-Electric Development. Irrigation was previously left to the States or private enterprise ; but since the beginning of this century, and increasingly after the Depression of the early 30's, the Congress has taken more and more active part in river training, which included navigation as well as irrigation, flood control and hydro-electric development. Much of this irrigation water came, it may be added, from the disposal of surplus water of neighbouring communities which had acute water shortage.

The same principles apply to rivers flowing through more than one Independent State. It has now been recognised that the territorial sovereign is not free to do what he pleases with the water upon his own territory. The complications and difficulties in the way of securing proper administration of Inter-Statal Rivers were settled by the Barcelona Convention in 1921 by the League of Nations, under which all Nations are recognised to have equal rights in International Waterways. These Waterways are to be administered by the Riparian States in their jurisdiction. But no dues, except for service actually rendered in maintaining the navigability of such rivers, can be charged ; and when such charges are made, they must be uniform among all Nations using a particular Waterway like the Danube or the Rhine which are outstanding examples.

A glance may at this stage be cast at the evolution of the administrative policy in regard to Irrigation and allied subjects in this country. Up to 1920 Irrigation was a wholly central subject ; and so all major Irrigation Works required the sanction of the Secretary of State. The Provincial Governments were associated in part from 1920 with projects of Irrigation ; but even then approval of the Secretary of State was necessary. They were concerned only with Irrigation, which was closely connected with their revenue ; and so all other uses of river waters were either neglected or remained with the Centre. After 1937, with the introduction of Provincial Autonomy, the actual day to day administration of all Irrigation Works in their area was made over to the Provincial Governments. But the maintenance of a uniform policy was rendered difficult by this development,

so that eventually a measure of common policy had to be evolved under a division of subjects. Under the Government of India Act, 1935, it is provided that:—

(a) "Shipping and navigation on tidal waters" is under the control of the Central Government (Item 21 of List I of the Seventh Schedule of the Government of India Act. 1935).

(b) "Shipping and navigation on inland waterways as regards mechanically propelled vessels, and the rule of the road on such waterways; carriage of passengers and goods on inland waterways" are subject to concurrent legislation of the Central and Provincial Governments (Item 32 of List III of the Seventh Schedule).

(c) "Communications, that is to say, roads, bridges, ferries, and other means of communication not specified in List I; minor railways subject to the provisions of List I with respect to such railways; municipal tramways; roadways; inland waterways and traffic thereon subject to the provisions of List III with regard to such waterways; ports, subject to the provisions in List I with regard to major ports; vehicles other than mechanically propelled vehicles are under concurrent powers of the Centre and the Provinces. (Item 18 of List II of the Seventh Schedule).

(d) "Water, that is to say, water supplies, irrigation and canals, drainage and embankments, water storage and water power" are under the exclusive control of Provincial administrations (Item 10 of List II of the Seventh Schedule).

(e) It may be recorded that "Electricity" is on the concurrent legislative list (Item 31 of the List III of the Seventh Schedule)".

The arrangement has in practice proved very cumbrous and unsatisfactory. The fullest possible use of our water wealth has not been made, whether for Irrigation or for Hydro-Electric purposes, while the conservation of the soil and utilisation of rivers for navigation purposes remains all but unknown. The Central Board of Irrigation, in their pamphlet "Waterways of India", suggest, in the over-all interests of the country, the following arrangement to share responsibility for the proper utilisation of water in the several respects in which it can be used :—

(a) Irrigation

(i) administration must be local and legislation required for this purpose should also be local.

For Regional waterways.

(ii) there should be an effective agency for co-ordination of activities of different units with respect to planning on and distribution of the supplies of such waterways.

(iii) there should be an agency for settling inter-provincial and inter-state disputes, and for this purpose federal legislation is needed.

(iv) there should be an agency for co-ordination of activities regarding research and improvements in technique.

(b) Hydro-electric development

(i) administration must be local, and legislation required for this purpose should also be local.

(ii) for development of hydro-electric power on regional waterways, the agency referred to in (ii) and (iii) of (a) above will operate.

(iii) Hydro-electric development in any region will have to be co-ordinated with the development of thermal power in that area. For this purpose federal legislation may be of assistance.

(c) Flood Control

(i) administration and legislation local, but for regional waterways inter-unit co-ordination of a very high order is required. The agencies referred to in (ii) and (iii) of (a) above will operate, and federal legislation will be needed.

(d) Navigation

(i) to be administered by the Union with the co-operation of units.

(ii) Legislation federal.

(iii) For local navigation, administration will be local; but it will have to be adapted to federal laws.

(e) River Pollution

Administration local but legislation may be both local and federal, the latter with regard to inter-state rivers.

(f) Fisheries

Administration local but legislation may be both local and federal.

(g) Recreation

Local.

(h) Soil Erosion and land treatment

Local administration ; but there may be necessity of federal legislation for inter-state rivers.

(i) Subsoil waters

Local.

These are lines of general policy which seem eminently suited to a comprehensively and scientifically planned national economy.

The several sections of the Reference to this Sub-Committee were entrusted to different members of the Sub-Committee. Only one of them, the Chairman, Nawab Ali Nawaz Jang, has prepared, in final form ready for printing, the sections of the Reference entrusted to him for reporting. Those in charge of water-supply for towns, and of communications by water, have not reported yet.

K. T. Shah.

PART I

REPORT ON IRRIGATION IN INDIA

1. **Preliminary.**—It must be stated at the outset that the Report is merely a preliminary survey of the vast and important question of irrigation, and the attempt is only to give an outline of the broader and more general aspects of the subject. India is a very large country, and the natural facilities presented for irrigation differ widely. To approach this very complex question convincingly and satisfactorily, an intimate knowledge of the conditions prevailing in the various tracts embraced is required. We must further have access to records in order to get a thorough insight into the extent to which opportunities for irrigation have so far been utilised, and the possibilities that exist for further extension. Such information as we have at present at our disposal is meagre and will need to be brought up to date. With a view to making a commencement, however, we shall attempt a general survey, indicating the direction in which further inquiries should be conducted to determine the lines of action.

2. **History.**—The practice of irrigation existed before recorded history. In Egypt, King Menes is said to have utilised the Nile for irrigation in 2700 B.C., and the ancient records of Assyria, Babylon, Persia, China, Mexico, South America, and of practically every country of antiquity bear testimony to this. In Spain irrigation has been practised for 3000 years. Irrigation in India must have been in vogue as far back as in any of these countries. Plant life is dependent largely upon the supply of water; and, as the rainfall is usually scanty, irregular, and spasmodic, the need for water in the quantity and at the times when it is most beneficial to crop production has to be artificially met. Irrigation affords ideal conditions for agriculture, which is thereby being reduced more nearly to scientific accuracy. In general, irrigation is most extensively practised in arid regions, where, without it, agriculture is precarious or impracticable; but it is also applied to lands of semi-arid tracts to increase the yields, and to certain crops in the humid regions.

3. The first attempts to supply the needed moisture to lands were primitive. Efforts were confined to assisting nature in flooding the low bottom lands with large volumes of water from rivers, and to raising water a few feet from pools to patches of land. The former had its origin in the natural flooding of marsh lands and the growth of grasses in the areas temporarily

submerged in flood periods. The next step was the more or less organised diversion of streams where the slope of the country and the topography were such as to present no serious difficulties; and the bringing to the surface of waters from underground sources. In certain tracts, conditions were favourable for storing the surface waters of small streams, and the facilities were taken advantage of for the construction of tanks. It was not, however, until recent times that the importance of stabilising the year-round flow of the rivers came to be recognised, and the larger problems pertaining to the storage and conservation of water supply began to be undertaken.

4. **Report of the Indian Irrigation Commission, 1901-1903.**— In 1901 a special Commission was appointed to report on the irrigation in India. The Indian Irrigation Commissioners were assisted in their inquiries by local knowledge and experience. They toured the country, took evidence, assembled data, and submitted their conclusions. Their report is a very valuable contribution, and should form the starting point of all further inquiry.

5. **The Water-supply of India:**— The primary factor in questions of water-supply is the amount of precipitation in the form of rain, dew or snow which reaches the earth. Not all of this, however, is available. The needs of nature have first to be met : there is evaporation from ground or water surfaces, and water is taken up by vegetation or transpired into the atmosphere from the leaves. Under the variety of conditions that prevail, it is not possible to estimate this toll taken by nature. But it is a very considerable quantity, and the common impression, that the rainfall minus the surface run-off represents the subsurface water-supply, needs to be corrected. A large quantity of water does percolate into the ground, and it is essential that a study of ground-waters should be systematically undertaken. But this again must not be held to be the measure of the potentialities of draft from wells. A fair proportion of this water ultimately reaches the streams and rivers through discharge by springs and by seepage. The ground-water reservoir is nature's apparatus, which, except for regulation by natural lakes, supplies the dependable or perennial flow of rivers. Without it rivers would go dry at times. For irrigation on a large scale, however, our supply of water may be practically said to be confined to what is reflected in the run-off, i.e., the visible surface flow.

6. The actual quantity of run-off depends upon such a multitude of conditions, many of which are variable, that the problem is not capable of mathematical treatment. For a rainfall under 20 inches, there is practically no run-off, except what may be due to excessive precipitation in short periods. The only reasonable way of determining the run-off is by direct measurement

of stream flows. In regard to the data for this, the Irrigation Commissioners recorded that " the necessary information is not available for many of the most important river-basins. " Some progress in this direction has been made since. It is, however, not adequate, and it is necessary to draw attention to this fundamental need of extending the system of permanent gauging stations on all rivers concerning which records of flow are important for planning water resources. Before any works affecting the control of a river are undertaken, it is essential that the fullest information concerning the volumetric discharge of a river should be obtained and carefully studied. It is only by establishing gauging stations and keeping careful records over a number of years that the characteristics of a river can be obtained.

7. The Irrigation Commissioners approximated the surface flow from an area of 1,434,000 square miles (excluding the the catchment basin of the Brahmaputra and that part of India which lies westward of the Indus watershed) to 51 billion cubic feet, on the basis of computation from the rainfall. From the enlarged data now available in regard to proportions of rainfall running off, we would estimate this at a lower figure. But, as remarked by the Irrigation Commissioners, a large part of the resulting surface flow is not, and cannot be made available for utilisation in certain tracts. Where the rainfall is high, there is little use of water, and there may be conditions not favourable for storage. The utilisable quantity is probably about 15 billion cubic feet, and of this it was estimated that 6.75 billion cubic feet were being utilised at the time for some 40 million acres of irrigation. The available surface flow is still an enormous volume considered as a whole, and the task before us is to utilise as much of it as may be practicable.

8. **Needs and Benefits of Irrigation.**—While the average rainfall of India is high, it is far from being equally distributed over the country. There are tracts in which the rainfall is so light that cultivation is not possible without an artificial supply, and there is a vast area in which the seasonal distribution is so irregular that there is lack of moisture at the times when it is required for crops. With these characteristics and continuous daily sunshine in the arid and semi-arid regions, irrigation affords ideal conditions for scientific agriculture, offering opportunities for diversity of production and larger yields than are obtainable in the humid regions. Irrigation in the arid areas is a necessity, and, if properly carried out, is a boon. An enormous extent of land is dependent upon irrigation for the products of high grade crops, and the products, equal in excellence and amount to those from the most favoured areas of rainfall.

9. The mean rainfall is no guide to the crop producing capacity, and even in tracts of moderately high rainfall (35 to 50 inches) the important factors are seasonal distribution and variability from year to year. Taking the latter as the general index of the need for protection by means of irrigation, the Irrigation Commissioners expressed the opinion that a deficiency of 25 per cent from the average rainfall would be likely to cause some injury, and that a deficiency of 40 per cent would generally cause severe drought. Fairly wide-spread droughts have resulted from a smaller diminution in rain. We have accordingly taken these percentages as 20 and 33 1|3 respectively, and, from the information supplied by the Meteorological Department, the record has been brought up to date. The average frequency of years of drought is noted below:-

Division	Average monsoon rainfall inches	Number of dry years or years of drought that may be expected in 62 years	
		Dry years including years of severe drought	Years of severe drought
Madras Coast, North ...	36	6	0
Central Provinces, East ...	47	3	1
–do– West ...	41	8	1
Bihar ...	41	11	2
Bombay Deccan ...	24	11	3
Central India, West ...	31	12	3
Berar ...	28	9	4
North West Frontier Province (a)	17	10	4
Hyderabad, North .	29	10	4
United Provinces, East :	35	10	6
Central India, East ...	35	14	6
Mysore, Maidan (b)	13	24	6
United Provinces, West ...	33	11	7
Rajputana, East ...	23	13	7
Punjab, East & North ...	18	16	7
Madras Deccan ...	15	18	7
Hyderabad, South ...	24	19	7
Gujerat ...	31	12	9
Rajputana, West ...	11	20	12

(a) Figure for average annual rainfall.

(b) Based on figures for 43 years only.

10. Gross Areas under Crop : The extent to which cultivation has developed will be seen from the following statement which shows also the unirrigated areas under the principal crops.

The areas are gross areas, that is, they include areas sown more than once ; and they were in 1937-38 :—

Crop	Irrigated area acres	Unirrigated area acres	Total cropped area acres	Proportion of irrigated to total area
Rice ...	21,127,477	56,020,671	77,148,148	27.39
Wheat ...	13,826,522	20,316,982	34,143,504	40.50
Barley ...	2,931,251	4,202,736	7,133,987	41.09
Jawar ...	1,033,549	33,000,657	34,634,206	4.72
Bajra ...	1,109,200	17,625,297	18,734,497	5.92
Maize ...	1,679,577	6,240,355	7,919,932	21.21
Other Crereals and Pulses ...	8,235,849	26,578,270	34,814,119	23.66
Sugarcane and other sugar crops ...	2,433,091	1,773,993	4,207,084	57.83
Other food crops ...	4,607,962	5,456,853	9,464,815	42.35
Cotton ...	5,419,449	17,445,920	22,865,369	23.70
Other non-food crops ...	6,694,223	41,345,778	48,040,001	13.97
Crops for which details are not available (in Indian States) ...	24,037	454,957	478,994	5.02
	69,122,187	230,462,469	299,584,656	23.07
Ragi ...	...	5,792,843	5,791,843	...
Gram ...	...	19,058,237	19,058,237	...
Total ...		24,850,080	24,850,080	
Grand Total ...	69,122,187	255,312,549	324,434,736	

Normally ragi and gram do not need irrigation, and the areas of these crops have, therefore, been excluded in srtiking the percentage. But if these be included, as was done by the Irrigation Commissioners, the percentage would be about 21.35 as against 19.5 for 1900-01. The rise in the percentage of irrigation is not much.

11. Comparative Extent of Irrigation in the Humid and the Arid Regions.—The following statement exhibits the distribution of irrigation in the different areas, the line of demarcation for the humid region being taken as 40-inch isohyet :—

Region	Annual net cropped area in millions of a res	Percentage of cropped area under				
		Canals	Tanks	Wells	Other Sources	Total
Humid ...	132	5.17	4.04	2.93	3.74	15.89
Semi-arid & arid						
(a) Alluvial ...	75	31.30	0.22	12.35	1.86	45.73
(b) Central tableland ...	81	3.73	3.11	3.07	0.43	10.34
Total ...	288	11.56	2.78	5.42	2.32	22.08

12. The humid region comprises a large area of cultivation, and here private enterprise has accomplished a good deal in the way of supplementing, through artificial means, the seasonal requirements of water. In general, however, the State works carried out so far have not been successful. The rainfall being high, the demand for irrigation water is not constant and sustained, and in this region the question of drainage is of even greater importance. Any considerable extension of irrigation depends upon the meeting of the latter need.

13. Cultivation in the arid and semi-arid zones is somewhat greater than that in the humid zone, and much of the present area of 156 million acres stands in need of protection. The alluvial plains offer great facilities for canals and wells, and these have been taken advantage of to a large extent. But the central table-land is very poorly developed, and the existing methods do not suffice. A large area of irrigation is to be found under the numerous tanks, there being, in some parts, one tank to ¾ square mile of drainage. These utilise the local rainfall which is neither copious nor certain in its contribution. The area watered by wells is inconsiderable, and one great advantage of extension of canal irrigation will be a rise in the spring level, thereby increasing the efficiency of this most useful class of work. There is great scope for extension of canal irrigation through provision of storage, as the higher slopes of the elevated plateaux have a humid climate, and the tract is traversed by the great rivers which come from there.

14. Areas Irrigated by Various Classes of Works.— It would have been interesting if we could give a comparison of the areas irrigated under the various sources of irrigation with those furnished by the Irrigation Commission for 1900-01. But we have not the material which will admit of any useful inferences to be drawn. The area comprised in India has altered, and it would seem that the statistics were not as reliable in 1900-01 as they are now. These factors can be allowed for, but the classification of areas under some of the sources has undergone a change that makes a comparison, in the absence of detailed information, not valuable. The following statement indicates

the state of irrigational development by each class of work for the year 1937-38 for the Provinces of British India and the Indian States :—

Province	IRRIGATION (in Acres)						
	Canals.		Tanks.	Wells.	Other sources.	Total area of land irrigated.	Total area of crops.
	Government	Private.					
Ajmere-Merwara	—	—	24,349	97,732	851	122,932	153,150
Assam	240	349,414	1,431	—	303,196	654,281	654,281
Bengal	197.652	246 216	1,044,646	50 039	501.770	2,040 373	2,053,662
Bihar	612,149	771,097	1,441 697	507,462	942,623	4,275,028	4,275,028
Bombay	263,919	73,107	113,393	604,791	40,175	1,095,385	1,281,913
Central Provinces & Berar ...	*	1,044,556	*	154,060	65,145	1,264,361	1,264,361
Coorg	2,411	—	1,667	—	—	4,078	4,078
Delhi	31,169	—	1,3 5	27,042	—	59,605	59,606
Madras	3,750,214	163 279	3,191,745	1,358.657	281,464	8,745,359	10,898,480
North Western Frontier Province	439,404	432.296	—	82,646	70,635	1,024,981	1,047,540
Orissa	304,407	54,004	294,902	8,335	700,720	1,362,368	1,526,199
Punjab	11,203,288	426 0-1	35,705	4,346,199	128,670	16,139 943	16,406,460
Sind	4 020,619	9,575	—	27,939	388,275	4,446,408	5,017,727
United Provinces	3,827,728	41,460	99,483	5,303,053	2,325,169	11,597,493	12,671,766
Total British India ...	24,653,200	3,611,085	6,250,463	12,569,155	5,748,693	52,832,596	57,314,251
Indian States	3,957,077	1,074,541	1,765,124	3,028,528	939,641	10,764,911	11,807,936
Grand Total ...	28,610,277	4,685,626	8 015,587	15,597,683	6,688,334	63,597,507	69,122,187

* Included under 'Private Canals'

15. Irrigation in the Province of Assam was not included in the statement of the Irrigation Commission. During the period of 37 years since that report, the gross irrigated area would appear to have increased by 16 million acres or about 30 per cent. It is highly probable, however, that the irrigated area for 1900-10 was overestimated, and that the actual increase has been greater. The information from the Indian States is not very complete, and there is a number of large works in British India which are still to be developed. Allowing for this, the total area of irrigated land may accordingly be approximated in the near future to 66 million acres, and of irrigated crops to 72 million acres. Of the irrigated land area 31 million acres will soon be from Government Canals and Reservoirs, 4½ million acres are from private canals, 8½ million acres from tanks, 15½ million acres from wells, and 6½ million acres from other sources. Over 40 per cent of the area of irrigation is dependent on private irrigation works.

16. In spite of this large area of irrigation.— the largest in any country of the world— it must not be thought that the possibilities have been exhausted. We have not the data to forecast the ultimate limit for irrigation with any degree of reliability. If the surface flow of India be taken as the criterion, our resources will not be found inadequate; it is the geographical distribution of the supply that will impose limitation. But there are engineering and economic questions involved, the former in overcoming the physical obstacles, and the latter in the limitations upon the amount of water which can be economically stored, and in the value of the supply with reference to the character of the lands to be watered. It is necessary to set about collecting the requisite data, because, of the resources available to man, water, being renewable annually, should be utilised to the fullest extent. Meanwhile we can only make a few general observations, and we shall take up first the classes of works other than 'Government Canals and Storage Reservoirs.'

17. Scope for Extension under the Minor Classes of works.— There is no great scope for extension under 'Private Canals': these works will gradually go out of use with the introduction of more efficient means of irrigation. Irrigation under 'Other Sources' admits of considerable expansion in the high rainfall regions and the submontane tracts; and every assistance should be given to private enterprise to develop this class of irrigation works—particularly in the form of small storages, which will be of special value during breaks in the rains. There are very extensive areas of crops now grown without irrigation which will in general benefit by an artificial supply, even in regions of heavy rainfall: unirrigated rice alone accounts for 56 million acres, or over a sixth of the total cropped area of India. Expert

professional aid will no doubt be needed, and arrangements should be made for it to be given through an adequate organization. It should be possibie to obtain an increase of, say, 5 million acres through this means.

18. Wells are a very efficient form of irrigation where underground water is at an economic depth, and where (as is frequently the case) the quality of the supply is not unsuitable. They offer scope for expanding irrigation in the submontane tracts and, as an adjunct to canals, add materially to their utility. Storage is not necessarily only in open reservoirs: storage under the ground is almost equally important, and perhaps more so. It must, however, be noted that there is a very limited field for the exploitation of this underground storage. Unlike the rainfall and the surface waters, the underground supply does not vary greatly between the wet and the dry years. The Irrigation Commissioners, estimating the volume of water expended on irrigation from wells at about one billion cubic feet, have recorded that this is "not more than 1½ per cent of that portion of the rainfall which penetrates the soil." This is obviously a statement carelessly made, as the Commissioners have themselves stated elsewhere that the difference between the total rainfall and the surface run-off represents the quantity "absorbed in sustaining plant life, in maintaining moisture in the soil, and in replenishing the subsoil water-supply, or is lost by evaporation." It does not merely indicate the contribution to ground-water ; the factors that go to make up the hydrological equation leave only a small share to join the water-table annually. Sub-soil supply is by no means inexhaustible, as is frequently believed to be ; and the problems of its best utilisation for irrigation are much more complex than those met with in the use of surface supplies. Their solution involves intensive research, investigation, and study, to determine the extent and availability of the supplies, and the relation between their use and depletion. Another matter to be borne in mind is that, while the total "under-flow" may represent a large quantity of water, it is an extremely slow percolation, usually not more than a few feet a day; and the amount available at any one point is small, owing to this slow rate of delivery.

19. It is evident also that, unless there are special conditions of climate, crops, and markets, raising water for irrigation cannot be justified with prevailing costs and crop prices. For pumping, the solution is to be found in the installation of a considerable number of closely located plants attended by one skilled man. and in producing sufficient water to serve a large acreage. In the United Provinces a beginning has been made in this direction, and we may look forward to a fairly rapid extension under this form of irrigation, which has remained almost stationary

in the past four decades. Irrigation by wells is adapted to individual effort, as the construction of a well, where conditions are favourable, is often not beyond the resources of an individual, and the area it will irrigate no greater than he can control. If proper encouragement and assistance be given, it may be possible to expand the well-irrigated area by five million acres. This is one-third of the forecast made by the Irrigation Commissioners.

20. Tanks are another useful source of Irrigation. Excluding the natural depressions and the storages created by very low bands in the alluvial plains, they may be said to be confined to the uplands of Peninsular India, and are to be found extensively in tracts where the rainfall is meagre. They vary greatly in their sizes, and present peculiar problems of a distinctive nature. The larger works are few in number, need considerable technical assistance, and require a large expenditure of money to make them reasonably safe against breaches. Government agency alone is therefore suited to the construction and maintenance of such works. But there are numerous small units scattered all over the country, the maintenance and repair of which by a Government Department might be said to offer as difficult a problem as maintaining village huts in repair. Further it has come to be regarded as an axiom by Irrigation Engineers that it is less costly in the long run to allow these works to breach every 15 years or so, than to go to the expense of preventing breakdowns under abnormal conditions. Their upkeep should be entrusted to the village communities concerned, who can give the requisite attention in time. This needs the formation of broad policies and the enactment of suitable laws to make the policies effective.

21. Tanks are expensive works both in construction and in their upkeep, and they are liable to fail when most wanted. As storages, however, they are very useful where the rainfall is ill-distributed. The scope for extension here is limited, as many of the suitable sites have already been utilised; and we should be inclined to put the forecast at 2 million acres. To this may be added another 1 million acres which seem possible of attainment by a sparing use of the waters under the existing work, i.e., 3 million acres in all.

22. Our estimate then of the increase in irrigation to be expected under the minor classes of works is limited to 13 million acres, bringing up the total area under this head to 48 million acres. The progress in these works is, however, likely to be slow. They are works mostly for private enterprise, and their extension can only depend on the strength of the resources of the people. Moreover wells and tanks are works which will in future be in-

creasingly resorted to for municipal and domestic supply, where they will be of the greatest value.

23. The figure given for extension of irrigation under the minor classes of works, viz., 13 million acres, seems to us to be the outside limit, and we regard the forecast put forward by the Irrigation Commissioners, of 16 million acres under 'wells' alone as oversanguine. Excessive draft of underground water will lead to desiccation of the water-table. It is the surface flow which holds out prospects of extensive use of water for purposes of irrigation. As far as we can see ahead, over 80 per cent of our irrigation is likely to obtain its water-supply by gravity from surface flow.

THE MAIN FIELD FOR FURTHER EXTENSION— 'Government Canals and Reservoirs.'

24. **The situation in Regard to Irrigation.**—The first thing needed is a clear insight into the existing situation. The old era, when water could be, and was, used without restraint and with lavish prodigality, is coming to an end. Flood irrigation was the first or pioneer phase. It had its origin in the level surface, and superior commands obtained in the alluvial tracts : the works needed were consequently not costly, as the water was taken to the extent of the low flow of the streams, and there were not many physical obstacles to overcome. In so far as the facilities were assisted by the unfailing supplies of large rivers, particularly snow-fed rivers we have utilised this system of irrigation to almost the highest degree possible; and we have done much towards improving the regulation of that supply by replacing inundation canals by weir-controlled canals, giving better supplies and for longer periods. We are now nearing the limit in the utilisation of the natural flow of our rivers, determining the area that can be safely brought under cultivation. There is a constant danger of scarcity of supply at critical periods, and the system does not admit of high duty being obtained out of the water. The supply is not sufficient, and it is becoming more and more difficult to meet our growing needs in regard to water, upon the conservation and use of which depends a large share of life, health and prosperity.

25. There is also to be considered the momentous problem of the irrigation of the upland arid tracts. We have become conscious of the fact that these areas, with a warmer climate, a powerful sun, and facilities for drainage, are better suited for high-priced crops and diversified farming. The largest bodies of irrigable land and the greatest opportunities are to be found along the greatest rivers in the arid regions: the soils are also much richer in mineral plant food. There is an aggregation of advantages in this region, and no tract can give more from the

artificial application of water. But for this, advance has to be made in the system of irrigation. The ensuring of a fairly uniform flow of water at the right time and place can alone make possible the numerous uses of water, including irrigation. Flood irrigation was a makeshift which has had its day, and the future development on a large scale is basically dependent upon well-considered plans of storage of the high water flow of the rivers. A careful study is, therefore, needed of all opportunities for providing large-scale storage reservoirs, as the handicap to agriculture can be remedied only thereby.

THE STORAGE SYSTEM OF IRRIGATION.

26. The need of water storage was appreciated by even the primitive savages, but its provision on a large scale is a matter of recent history. While throughout historical times there was some progress, it is the present century that is particularly notable for the great increase in the size of storage works. Early in the century the Irrigation Commissioners recorded that the combined storage capacity of reservoirs in Bombay and Madras was about 30,000 m.c.ft., the largest, viz., the Periyar Lake, holding above outlet level 6480 m.c.ft.; and in Mysore the Marikanave Tank was designed to store 30,000 m.c.ft. Large-scale storage was not a live issue then, and on an inadequate experience of these first attempts they pronounced the word 'storage' to be "as suggestive of the limitations as of the possibilities of irrigation as a means of protection," because, it was said, of "the great cost and uncertain operations."

27. There are, it is true, limitations, and these arise from two main causes:—(1) hydrographic, and (2) topographical. Not all the water of the flow of the rivers is available for storage; neither, as is popularly supposed, is the building of reservoirs always practicable from the physical and economic view-point. In determining, therefore, the quantity of water that can be economically held, enthusiasm must not be allowed to outrun judgment. With this caution against extreme views, the domain of irrigation is not restricted within narrow limits. Our water resources are great, and there are many natural facilities for storage. In the United States of America, where the largest storage works have recently come into existence, the quantities of water available at the head-water basins are usually scanty; and, to secure adequate supplies, reservoirs have had to be located in the lower altitudes. In contrast with this, the mountains of India are regions of heavy and unfailing rainfall, furnishing rare opportunities for irrigation and for development of water power.

28. The operations of storage works are in no way "uncertain": in fact there is no safe basis of expansion but regulation of a river, which will give a larger water-supply when the river is

low. The impracticability of holding up water of favourable years as a provision against years of drought appears to be the main reason advanced. Long time storage will undoubtedly be subject to serious loss of water; but the Irrigation Commissioners have themselves recorded, even in the case of storage works not situated in the regions of unfailing rainfall, that "experience shows that failure occurs less often than might be supposed." And we may refer to the Elephant Butte dam on the Rio Grande, where the annual fluctuations of the river range between 2,422,000 and 200,700 acre-feet, and where a storage capacity of over 2,600,000 acre-feet has been provided, in order that some of the water may be carried over for years of drought. This, however, is not the normal function of irrigation storage : water is a resource that is renewable from year to year ; and with its preservation for any length of time, the question of irrigation is not much concerned. To enlarge the boundaries of irrigation, and increase the yield and value of crops, storage has become a *sine qua non.*

Cost of Storage.

29. The side of the question which really needs consideration is whether the practical application of the storage reservoir system would produce results commensurate with the cost. Undoubtedly this is an expensive undertaking: there is the cost of provision of storage, and there is also the increased cost of canals to deliver water, due to the undulating nature of the country, and the necessity for providing masonry works across the numerous torrents which carry its drainage. Now, if the results from this system are to be the same as those under flush irrigation of low bottom lands, it goes without saying that the former system will be at a great disadvantage. The fact is that irrigation in the arid uplands cannot be thought of on the analogy of the canals in the alluvial tract. It is of a superior class, and the results can also be higher. Larger and better crops can be obtained, water can be economically employed, and the whole cost of storage need not be charged to irrigation, as water can usually serve other purposes as well.

30. In making this statement, we are not referring to the small storages on dry catchments for local use which have existed from time immemorial in the shape of tanks, and which will continue to be constructed in spite of their cost. These works spread out the benefits of irrigation over wide areas, and in them are involved the good name of the State and the well-being of the people. They will mostly be unproductive, and the expenditure on such works will have to be met from general revenues, and the net financial burden borne. Excluding these, there is no reason why the storage system of irrigation should not offer a promising field for financial investment.

POTENTIALITIES OF EXTENSION BY PROVISION OF STORAGE

31. We made a conjecture in regard to expansion under the minor classes of works, because we are convinced that there is a definite limit in that sphere. Whether the additional area actually turns out to be 13 million acres or 15 million acres, is a matter of little moment to the total irrigation. For any considerable development, our efforts should be directed to the provision of storage, wherever it is economically feasible. One does not need to look ahead even a quarter of a century to realise that our growing demands will be far greater than could be met by the unregulated discharges of rivers.

32. To form an estimate of the possibilities of this class of work, the requisite material does not exist, and it is desirable to avoid eulogy. It may be that the surface flow of our rivers, including the Brahmaputra, is an enormous volume, amounting to some 50 billion cubic feet. But, whereas most of this water could be used to generate power, only a fraction is employable for irrigation. In the valley of the Brahmaputra or of that of the Lower Ganges, there is little need for irrigation, and this applies also to the large quantity of water that drains into the Arabian Sea from the Western Ghats. We know that some of this water from the Western Coast can be diverted for utilisation in the eastern table-land, but it can only be to a limited extent. The contribution from these catchments of heavy rainfall to the total surface flow of India is more than half; between them the volume of water is equivalent to the flow of about 5 rivers of the size of the Nile; while the prospects of utilisation in these humid areas can hardly be estimated at 15 per cent. of the surface drainage. In several of the other tracts there are also very definite limitations. The maximum amount of utilisation might approach the figure of 17 billion cubic feet; and with efficient management and prevention of waste we may look forward to an irrigation of 110 million acres of land from this quantity of water. Allowing 60 million acres for the probable extent from the other sources utilising the surface flow, the estimate of potentialities under "Government Canals and Reservoirs" may then amount to 50 million acres.

33. Such a forecast, of the very roughest, can merely be of the nature of a hope. The proper course is to assume a limited period. The Irrigation Commissioners had outlined a construction programme for British India, which was for an extension of about 6 million acres in 20 years under this class of works. What has actually materialised may be said to be twice the area in twice the time. This rate of extension is not commensurate with our needs, and should be trebled. We fully

realise that the hydraulic works have been built to a point where the easily available sources of water have been utilised; and that future progress, dependent mostly upon use for power as well as for irrigation, will involve greater cost per m.c. ft. of water made available. Nevertheless, we do not think it over-sanguine to look forward to an addition of 16 million acres in the century; and the range and intricate character of the the next two decades for all India, including the States.

IMPORTANT PROBLEMS OF FUTURE PLANNING

34. To meet the demands of the future, our rivers have assumed a value which was undreamed of at the beginning of the Century; and the range and intricate character of the physical facts involved in this great task call for effective planning on systematic and scientific lines. Irrigation is as old as civilisation and we are nearing the end in the matter of dealing with alluvial tracts, which are well adapted to the distribution of water. In regard to water storage, however, there has not yet been developed a consistent theory based upon economic considerations, though some of the largest and highest dams in the world were built by the United States Reclamation Service in the period from 1904 to 1914. The question of the overcoming of physical obstacles in the broken surface of the uplands is only one of the problems of the new economic era to be inaugurated; and it is not surprising that such undertakings were regarded with great apprehension by the Irrigation Commissioners. A development depending upon storage of the high flows of rivers involves a great variety of questions, needing research, investigation, and the assembling of data and their analysis. We shall proceed to consider the more important of these questions.

35. **Policy of Large-scale Storage.**—For well-considered plans of large-scale storage, we cannot subscribe to the view expressed by the Irrigation Commissioners that "it will of course be unnecessary to provide storage in excess of what is required for the area"; nor their suggestion for numerous storage works. The latter policy may be sound in regard to tanks, which are works dependent on local rainfall in dry catchments. But for the abundant supplies of large rivers from regions of copious and assured rainfall, it is unsuitable. The supply is not merely for the small area that is available in the Province or State in which the site of the storage reservoir may be located: it is for the whole river valley, the people living in that great basin being bound together by a common tie of dependence. It is a question of obtaining as full control as may be possible, and not merely one of expediency limiting storage to what is immediately required for the area that can be brought under command within a particular province or State. Instead of a large number of

small units, we need a few strong works of large size, so as to reduce as far as possible the cost of storage and the evaporation losses consequent on exposure of bodies of water to the sun and the wind. Small storage mean decrease in efficiency and utility, and may even be a menace to further development by the accidental establishment of rights.

36. There is also the problem of transmission of water to be considered. The site favourable for a reservoir may not suit as off-take for the alignment of a canal; the area under a canal may be such that a plentiful application of water may do it harm; or it may be that the conditions of soil or climate will give a greater value to water in irrigation lower down the valley. In the central table-land, however, there is usually no difficulty in utilising river-beds as a means of conveying water. Here rivers flow in the lowest parts of the valleys, and generally the beds are rocky without any subterranean passages through which water can be lost underground. We are, therefore, favourably placed in this matter of transmission, which has a very important bearing in the extensive use of water: the only loss may be said to be that of addition to evaporation.

37. As a corollary to this, tracts should be commanded by means of canals not too long. Considerable lengths of canals mean loss of water and great increase in cost of delivery. Even in Northern India, where there is the advantage of water being cheaply obtained, transmission through long canals tells heavily. The defect of conveying water as much as 350 miles along the Upper Ganges Canal had afterwards to be rectified by the construction of the Lower Ganges Canal, which relieved the upper work from the irrigation of 128 miles of the Cawnpore Branch and 130 miles of the Ettawah Branch. The Tungabhadra Project of Madras is an example from the Deccan. An important objective of the scheme, as originally contemplated, was the carrying of water to the coastal district of Nellore. For this, water had to be conveyed in a canal length of 132 miles, after which there was run of 170 miles in the wide sandy river-bed of the Pennar, before it was taken out to be used. The loss consequent on the attempt to lead water this long distance militated against success. Examination of the figures given in the Project Report shows that the Tungabhadra Reservoir and the Main Canal from it had to be designed to draw off 2 2/3 m.c.ft. for every one m.c.ft. which would find its way to the Nellore irrigation system.

38. **Need for Detailed Land Classification.**—Even more important than these questions of storage and transmission of water, is the question of selection of lands that are worth irrigating. At present the Revenue survey records class as cultivable a large area of land which is so poor indeed that it cannot

be irrigated with advantage; also there may be tracts of undulating lands where the slopes are stony and have but little soil on them. It is essential that the soil should be of a good order of fertility, and we must have a detailed land classification to determine whether the land is worth the water to be applied to it. The water resources will ultimately limit the productive capacity, and should not be used so as to be out of balance with the lands proposed to be irrigated.

39. The limit of profitable economy in a comprehensive plan designed for the benefit of the whole country is to use the least quantity of water necessary to secure the best yield, and there should be no hesitation in allowing water, which cannot be profitably consumed, to run downstream where it can be applied on better soil, the cost of storage being charged. There are many uses besides irrigation to which water is put. If, for instance, an upper Province or State is in a better position to develop power, thereby conserving the fuel resources of the country, and a lower State is more favourably circumstanced to add to the food supply, the use of water should be arranged for on that basis.

40. Combination of Irrigation with Other Uses in the Regulation.— The facilities provided by storages are not merely confined to irrigation, and it is unfair to extract the whole return from the irrigation users, simply because they are faced with an emergency. Our view-point here must change, and it is desirable to explore possibilities of multiple use, involving combinations among supply for irrigation, dietetic purposes, power, navigation, flood control, sanitation, and even recreational features. Some of these by-products will greatly reduce the swollen burden which now falls on the irrigators—particularly power which normally is an income-producing factor of great significance. Storage is manifestly entitled to a fair, full and reasonable profit for all the work it performs.

41. We may divide the use of water under two heads:—(1)the use of its inert corpus, and (2) the use of its energy. Viewed in this light, the maximum benefit to the community demands reduction of the consumptive use in the head-water regions of rivers to the lowest quantity that may be needed, as the charge for water here must necessarily be high to compensate for the loss of power. The use of the energy of water is becoming of increasing importance, thus helping materially to reduction in the cost of storage otherwise chargeable to irrigation. In developing our water power, we shall be saving our resources in fuel, which have required untold ages for their accumulation; and it must further be remembered that, in spite of the improvements that may be effected in thermo-electric

plants, the cost of generation by coal, oil, or natural gas is likely to increase. As a rule, the use of water for power is not inconsistent with its economical employment in irrigation, while irrigation affords large outlets for the use of excess power. The pumping of water from wells and canals, and the facilities offered for the reclamation of water-logged areas and for processing the crops, their transportation, and other minor industrial purposes, are peculiarly attractive propositions. Cheap hydropower also makes possible the manufacture of certain chemicals, particularly the fixation of nitrogen from the air, to form the basis of agricultural fertilisers.

TERRITORIAL DIFFICULTIES AND DIVIDED CONTROL.

42. A serious obstacle to the development of irrigation is the division of the human community into several political jurisdictions. The Irrigation Commissioners pronounced this difficulty imposed by artificial conditions as one of the limitations of irrigation. Various interests and conflicting water rights have to be reconciled. Part of the country is humid and other parts are arid: and the doctrine of riparian rights has so changed in character in respect of the latter that its ancient landmarks can no longer be recognised. In the absence of any workable law or regulation concerning the division of water over State lines, no one knows what sort of obstructions will arise if the attempt to use the waters of a river were made. Our conception must change, and a river should be regarded as one natural economic unit for the benefit of the whole community it can serve, in the full development of which political frontiers must not be allowed to interfere.

43. Experience has shown that no enduring prosperity of the tillers of the soil can be built on divided control of land and water. The water titles are uncertain, and perhaps this is a matter of slow evolution by stages. But it is very desirable that the collection of the requisite information should not be neglected, as is the case at present, nor should it be left to judicial authorities to perform the duties of hydraulic engineers or irrigators. A specific course must be laid down, and we suggest the establishment of impartial and competent Inter-State Water Commissions to regulate, for the greatest benefit of the Provinces and States concerned, the use of the water of rivers which are their common property. The question arises in connection with every one of the uses to which water is put.

YIELD PER ACRE

44. Our efforts to increase the irrigated area will be of little avail, unless we take steps at the same time to realize higher crop values on the lands. This is a matter of even

greater importance. Before the War, the average value of crops, raised on areas receiving State irrigation, worked out to Rs. 30-8-0 per acre, and even in the Province of Bombay where high-priced crops are grown, the value was only about twice as much: whereas in the United States of America, several million acres of land, which were desert a few years ago, were converted into farms producing crops valued at 40 dollars per acre. We give below a comparative statement showing for the principal crops the yield per acre in India and in certain other parts of the world:—

Country	Yield per acre.			
	Rice husked lbs.	Wheat lbs.	Sugarcane tons of cane	Cotton bales of 400 lbs.
India ...	939	774	15-29	0.32
Egypt ...	2,976	1,913	31-19	1.33
Japan ...	3,437	1,706	25-14	0.50
The United States of America ...	2,181	816	19-26	0.70
Italy ...	4,549	1,383	...	...
Bulgaria ...	1,792	1,202	..	...
Spain ...	5,542	676	...	...
Java and Madura ...	1,366	...	49.38	...

The figures for India are averages for both irrigated and unirrigated crops, as we have not full information for irrigated crops alone.

45. Several authorities, some of them eminent Irrigation Engineers, have complained that the yield in India is low, implying thereby that the country is poor in this respect. Averages are generally misleading, and there is a cartain amount of confusion in this comparison. Taking for instance the case of rice, India has 77 million acres under this crop; but of this area about 73 per cent. is rain-fed, 22 per cent. is either under scattered small tanks or is river-fed, and hardly 5 per cent. is under modern storage reservoirs, where supply of water can be effectively regulated. It would not give a fair picture to make a comparison on the basis of averages, with countries where the area is small and cultivation is done with great care: Egypt has 495,000 acres under rice, Italy 367,000 acres, and the United States of America 1,076,000 acres. The source of supply has to be considered: both in quantity and in quality, rain-fed rice must necessarily be inferior to river-fed rice, and river-fed rice inferior to that under the well-controlled supply from storage reservoirs. There is no inherent defect of soil or climate over the greater part of India. The higher yields in the foreign countries mentioned are not the result of any better natural conditions.

46. Nevertheless, the yields in India from irrigation are very poor. Large yields are obtainable if we control and apply the moisture as and when needed, and adopt better methods with more wisdom in planting and harvesting. The Indian cultivator usually drowns rather than irrigates his rice. He takes as much water as he can get, as it is not easy to oversaturate paddy fields, and it saves him labour: less water means more labour to him. It is not realised that, on a supply of 75 per cent of the water utilised under ordinary conditions by ryots, the out-turn obtainable may be 150 per cent. of what is now returned, or even more. When properly irrigated, experiments have given 3400 lbs. to 4400 lbs. of rice for bumper crops. The cane used by sugar factories in the canal areas of the Province of Bombay shows a tonnage of 39¾ per acre. Such figures indicate the possibilities of increased yields in the arid uplands of India under controlled irrigation.

47. We may boast that India is the greatest irrigating country in the world and point also to a large area of crops well watered by nature. But people handling the soil are being permitted to exhaust its fertility, and little effort is made towards the cultivation of crops which will put nitrogen in the soil in order to maintain or increase the fertility. It has been deemed enough that the land be watered, and thought is not given to the fact that crop and land both suffer from a surplus of water. There is not simply a loss of water, but a far greater loss takes place by the removal of soluble substances from the soil which are an important part of plant food, or by the bringing up to surface of excessive alkali. The questions of the proper use of land and of the most economical application of water need early attention, as the problem that is facing us is that of increasing the productivity of the country. If India is not to depend on other countries for the supply of her every-day needs, we must improve the efficiency and turn-over of her productive process.

THE PROPER MANAGEMENT OF IRRIGATION.

48. The real elements of success are more dependent upon proper relations with the water users and with the soil, than upon the works themselves. Irrigation should be viewed as a nursery of co-operation; and there is the need of organising communities for the distribution of water under fixed rules and discipline. The purpose is the delivery of water at such times and in such quantities as will enable the largest and best crops to be produced. But in carrying out this purpose the principle to be pursued should be "efficiency first and then economy," so as to secure the co-operation of the irrigators.

49. Besides this community co-operation, there is the question of irrigation management. At present irrigation is con-

sidered as nobody's child, with the consequence that the interests of the people are suffering. There has not been so far any general recognition of management of irrigation systems as a distinct profession, for which men are to be trained by a systematic course of observation and study. On this hinges much of the success and prosperity looked forward to. The problem of organisation is inseparably connected with irrigated agriculture.

THE RATE OF INTEREST TO BE ON IRRIGATION WORKS.

50. We hear so much of greater importance being attached to the protective value than to the merits of irrigation schemes considered as financial investments, that it seems necessary to refer to the return that is laid down as test for a productive work. The rules make it essential that a productive scheme shall show direct profits from the sale of water sufficient to cover all working expenses and 6 per cent upon the sum-at-charge 10 years after the date of the completion of the work. We may accept as reasonable the assumption of the Irrigation Commissioners that the accumulated excesses of interest charges over net revenue at the end of the tenth year after completion, will be about 1|3rd of the capital cost, though this must depend upon the rate of interest charged. The codal definition demands, then, that the return should be 8 per cent on the actual capital outlay from irrigation, when it is fairly developed. This is not in keeping with the sentiment expressed, and it is here that the severest blow has been dealt to the interests of irrigation.

51. At the time of the Irrigation Commission, the rate of interest charged was much less, viz.,3¾ per cent. It ought to be still lower. The indirect benefits from irrigation are great and incontestable, and the view that a scheme, which could not with certainty yield a profit of 5 per cent. after paying working expenses—let alone 8 per cent—would be running at a loss, is retrograde. **We are definitely of the opinion that the rate of interest should not exceed 2 ½ per cent., and that, in the case of protective works, the revenue deficit in the early stage of development should be borne by the State.** In the United States of America, the Central Government provide the capital for large irrigation works, and on completion, hand them over to the local State authorities for operation, the responsibility of the State being confined to the repayment of the capital in easy instalments, but without any charge for interest. The consideration is that every new work, by increasing the prosperity of the country, is a source of revenue to the Central Government. The Central Government here should also lay down a policy as to the share they will bear, or the requisite relief might be given from the famine reserve. Of course, if the rate of interest at any time is very high, progress on works must slow down.

SOME UNTOWARD EFFECTS OF IRRIGATION.

52. Water is a great need of life, but it is a menace when not properly used. We have been laying stress on the great importance of using just the requisite quantity of water. Irrigation is supplementary to rainfall, and the problems are:—(1) to give an artificial supply when the water content of the soil drops below a certain point, and (2) on the other extreme, to remove the excess of water by drainage. When there is more water than the soil can hold, seepage with all its dangers begins. Excessive water and the condition brought about by percolation and seepage, from carelessly constructed canal distributing works intercepting the natural drainages, have developed various disorders. Some of the most fertile tracts have been reduced to malarial swamps, and there are districts suffering from an epidemic of fever due to the stagnant condition of their drainage courses.

53. In humid regions, even where irrigation may not be practised but where water is in excess, it is regarded more as a nuisance than as an essential element of life. Several alluvial tracts are suffering from a surplus of irrigation water. Mesopotamia was a country once fertile, beautiful, productive, and densely populated : today it is almost a barren desert, with alkali swamps and shifting sands. Over-irrigation is a grave danger facing the development of the arid region. In Bombay-Deccan, where the character of the soils and the topography of the arable lands are such as to call for a small quantity of irrigation water, an intensity of about 60 per cent. is aimed at in the perennial reaches of the canals. The intensity is too high for a soil from which the earthy alkali salts have not been leached out; and the consequence is that land, one of our greatest assets, is thrown out of cultivation. It is reported that 59,000 acres have been damaged in this way, through water-logging and salt efflorescence, under the Nira, the Pravara, and the Godavari Canals. The damage is enormous, the area representing more than 25 per cent. of the actual area of irrigation, viz. 214,000 acres, from these canals.

54. For land to function properly, the pores of the soil must be kept open, permitting it to be warmed and purified through aeration. If the soil gets so firmly compact that water cannot move freely, there is water-logging ; and where there are dissolved salts, alkali soils are formed as the result of a high water-table, and the land becomes "salted". The question of drainage is thus closely related to that of irrigation. Good drainage conditions mean total absence of free water in the soil to a depth well below that of root penetration, so that there may be circulation of air. Reclamation by drainage is thus becoming an im-

portant issue; and it has to be added that drainage, even more than irrigation, is a community problem and requires joint action.

55. Drainage for the prevention of malaria has a well-established technique, and methods to prevent its production are known. Projects, however, for lowering seepage and alkali on large irrigation canals, or for lowering comparatively level lands, where the soil is heavy and the under-drainage poor, present serious difficulties. Here the problem is not merely one of surface drainage: it is the underground drainage that is significant, and no attempt to relieve the low lands of an excess of moisture by deep drains may be of any help. It is not possible to avoid heavy falls of rain, nor is it even practicable to deliver just the minimum quantity of water on to the land that will insure the production of a good crop. It is therefore all the more important to apply water sparingly in order to maintain irrigable land in a productive condition.

CONCLUSION.

56. The growth of the country has been keyed to its irrigation development, and this relationship must be retained in the future. But the simple water diversions are exhausted, and the unregulated flow of the rivers has become insufficient to meet the needs. We have reached a stage where we cannot take or squander water unconcernedly; and there are problems to be faced in combating the adverse forces of nature and the obstacles created by man through territorial divisions of the country. We have laid stress on the wide field for development in the arid and semi-arid sections. Here irrigation is essential as a means of aiding this part of the country to help itself: the matter is one of national interest and attention. Storage of water is the crux of the problem of the future. It undoubtedly adds to the cost; but there are several uses to which water can be put, and these will, to a great extent, help towards attaining financial security. One of these by-products is power, which is normally an income-producing factor, and should be made available for widespread use.

57. The question of prudent economical utilisation of our great water resources should be examined far more closely and exhaustively than has hitherto been attempted: it will be necessary to study river basins instead of selections of streams. For this examination, what is required is one or more experienced and disciplined organizations which will see the problem as a whole, without special interests and in good perspective and proportion. Such organisations, as water Control Commissions and a general National Resources Board would seem to be called for with the object of over-all planning. As the works will have

to be carried out on a scale, and with a precision, beyond the capacity of an individual, provision should be made at the same time for the complementry task of supervision. A working outline for the administration is also needed, as well as the development of a spirit of co-operation among the water users themselves.

PART II

Report

on

RIVER TRAINING

and

PROTECTION AGAINST FLOODS

by

NAWAB ALI NAWAZ JUNG BAHADUR

F. C. H.

RIVER TRAINING AND PROTECTION AGAINST FLOODS.

1. **INTRODUCTORY:**—The problem of floods is an age-old one. Ancient legends refer to great deluges in the past which practically wiped out people, leaving an impression on the human mind of the overwhelming damage wrought. Rivers are disorderly natural facts and are themselves subject to disorderly supplies of water. The object of river control resolves itself into dealing with alternations of drought and flood; and it has taken the repeated lessons of deficient water supply, and of damage and intolerable drainage, to reach the view now held. Insurance against floods and against drought is among the most important undertakings of mankind.

2. Flood control engineering, however, is still in its infancy, and the administrative procedure applicable to flood control is not yet fully developed. We have so far confined ourselves to merely temporary expedients which have proved to be of little avail. The first condition of success lies in the recognition of the essential unity of each river system, and consequently the need for harmonious and concerted action by all the States interested in the waters. Also it is necessary to appreciate correctly the advantages that will accrue from flood prevention. Floods are calamities which occur occasionally, and the advantages from their prevention are largely indirect. It requires a more profound insight to appreciate the indirect advantages than does the commercial sense to foresee the financial profits only. Even now water control planning must continue to be a process of give and take, of protecting as much as we can of potential values, while getting as much as is feasible of present benefits. Impetuous action would be dangerous in this sphere: slow and careful progress is the proper mode of advance.

FLOOD RAVAGES.

3. The damages wrought by floods are serious, and, whether it be true or not that floods are becoming greater and more frequent, the losses they cause are increasing rapidly. These losses may be either direct or indirect. Direct losses comprise the destruction of, or physical damage to, property, such as injury to buildings, destruction of crops, live stock losses by drowning, and damages to rail-roads, streets, bridges, telephone services, water-works, sewers etc. The indirect losses are those resulting from decreased industrial, agricultural, or commercial activity during the flood and the period of recovery. To the ruin and desolation thus caused have to be added the epidemics which follow: malaria has been usually responsible for no less havoc than the floods themselves. But to justify a control plan, floods cannot be considered seriously as a menace to life, as life alone

can be protectd without construction of any flood works at all. Fatalities are usually the result of the natural reluctance of the people to abandon their homes and possessions.

4. To a considerable extent the trouble is of man's creation. People in striving for their living have not taken into account the risks involved: lands have been occupied on which nature has not accomplished her work, and which are not really fit for human habitation. In the upland tracts river floods are of little importance, and the damage done is comparatively slight. It is in the lower reaches of rivers that great loss is caused, and the primary need for prevention or protection has to be met in the interests of a prosperous population. Here rivers have to be converted into efficient flood carriers.

CAUSES OF FLOODS.

5. Floods are primarily due to rainstorms of extreme violence occurring in a short time, and to stream channels not having the capacity to carry the maximum water without rising above their banks. The features of the drainage basin have an important bearing, and the run-off of water is affected by such factors as the geological structure of the basin, the inclination of the ground, the tilling of it, the rapid thawing of snow, etc. There are further certain exceptional causes of floods, such as landslips or ice-jams closing for a time the outlets of valleys, accumulating large bodies of water which ultimately burst their barriers; the simultaneous or successive bursting of a series of artificial reservoirs or tanks constructed in a valley; volcanoes sweeping down torrents; and earthquakes tending to level up and reduce the channel sections of streams. In the alluvial tracts the rivers are generally incompetent to discharge the water brought down in the flood season. Rivers here are land-building rivers, i.e., they are performing the process of gradually raising low-lying lands. In this process the land remains mostly below the level of the floods, and the rivers normally overflow their banks. It leads to a position of unstable equilibrium, and we have to face the problem of rivers perpetually changing their courses.

6. Trouble is caused by the physical conditions of tidal rivers, the effects of which may be felt for more than a hundred miles from the sea. In tidal rivers the direction of flow is continually being reversed, and salt water, of greater density than fresh, has to force its way against a current coming from the opposite direction. Such tidal flow has been known to amount, in certain cases, to several times the maximum fresh water flow of the rivers. There may also be other factors to contend with, such as the formation of bars at the mouths of the estuaries, and the operation, along the sea coast, of a steady littoral drift.

7. There are, broadly stated, three sets of conditions, each one different in the aspects presented, viz., the conditions in (1) the non-alluvial areas, (2) the alluvial areas, and (3) the tidal areas. Destructive floods occur with more frequency in the second or alluvial areas, and the great struggle throughout the alluvial plains has made the history of civilisation the history of river protection and training. The alluvial areas are very large in extent and their prosperity hinges on floods being brought under effective control.

PRIME IMPORTANCE OF MAINTAINING RIVER SYSTEMS IN EFFICIENT WORKING ORDER.

8. Attention has to be drawn to the conditions brought about by man's activities or his neglect to take precautions in the use of land and water. They constitute that phase of the problem in regard to which united action is indispensable to success, and on which consequently the National Planning Committee should lay special emphasis.

9. One of man's errors has been his refusal to recognise the rights of rivers to floodways of sufficient capacity to deal with the maximum amount of water delivered to them. People and industries have been occupying river channels, and the flowage ways have been restricted by filling. Spill areas have been prematurely reclaimed, and reclamations have been allowed to take place even within tidal basins and in river estuaries. Not infrequently, Roads and Railways have come to be constructed without sufficient water-ways being provided. There are numerous other obstructions to the free flow of flood waters, and, if our great rivers are to perform their functions efficiently as flood carriers, the obstacles to flow should be removed. In saying this it is not intended to suggest that summary action must be taken to remove forthwith every encroachment. The process will have to be gradual, and, if certain existing vested interests are regarded as insuperable, means will have to be devised at least for alleviating their effects. What is desired to stress is that in future the utmost care should be exercised in preventing commercial developments on land which is not fitted by nature for human occupation. If the rivers are to flow in a stable regime, State action is needed for the proper planning of settlements.

10. There is another — and still more important — side of the question. It will be noticed that except perhaps in a few instances, where the rainfall is fairly well distributed through the major part of the year, or where snows and glaciers provide storage on an unrivalled scale, the chief characteristic of our rivers is the tremendous variation in flow between the seasons.

The question before us then is not just one of reducing flood peaks but of increasing the low-water flows as well. If the rivers are not to deteriorate in the lower reaches, and if the silt and detritus brought down from the uplands is to be carried forward without choking the waterways, supply of water in adequate quantities has to be furnished outside the short abkalani period. Improvement in the disparity in flow between the seasons is an important means of bettering the conditions, and it is the want of recognition of this need that is at the root of most of our troubles.

11. There are forces in operation tending to exhaust the dry weather flows of rivers. On the one side, man has contributed to the present unsatisfactory state of affairs by such harmful acts as the stripping of forests, unnecessary removal of plant cover, improper methods of cultivation, and extensive grazing from an animal population out of proportion to what the country can bear without deterioration: further, with the increase in the human and the animal populations, the problem of soil erosion has, within the last three-quarters of a century, assumed enormous dimensions. On the other side, we are abstracting the low flows of the rivers and impoverishing the perennial springs, in the attempt to meet the continually increasing demands for water. The effects of all this have made themselves apparent in the alarming lowering of the mean water level, and not less so in the gradual increase in the dryness of the ground. Moreover, whereas the normal tendency in the regimen of a river is for its flood-plane deposits to grow finer, the process is now changed, and the deposits are growing coarser. Rapid run-off and coarser sedimentation in rivers are nature's ways of telling us that our agriculture needs tuning up. With the soil swept bare and exhausted by abuses in its handling, the stream which can be utilised is disappearing, giving place to the devastating torrent in the upper reaches. In their lower reaches, rivers are behaving more and more erratically owing to the flow and the velocity being inadequate for the transport of the sediment burden. The very existence of the rivers is, in fact, in danger.

12. An increase in human population necessarily entails drastic changes in the hereditary agriculture of the community; and the destruction of plant cover brings a country climatically somewhat nearer to desert conditions, if steps are not taken to reduce the inevitable loss and desiccation to the lowest possible rate. The detention of water so as to stimulate the run-in, and the reduction of silt and detritus, the recurring deposit of which greatly complicates the work of river improvement, are the principal protections against the troublesome flood and the low-water extremes of rivers. Land systematically terraced is able

to deal with most of its own rainfall, and the surface wash being minimised, remains much richer in time, phosphoric acid and total nitrogen: soil fertility will increase and more permanent agriculture will result. There should also be the greatest practicable promotion of forest culture: afforestation will not only prevent steady and rapid exhaustion of our timber resources, but will increase the sub-surface storage, and is a simple, cheap and effective means for securing the heavy slopes of land, and for keeping the pebble shoals down.

13. It is however necessary that in this, as in other matters, things should be seen in their right proportion and not distorted. Men tend to go to extremes. Some believe that good cultivation, and the preservation and extension of forests, would do away with floods entirely. Others go into rhapsodies over the inexhaustibility of the underground flow of sub-montane tracts, and proceed to take measures which result in the desiccation of the water-table. The pre-requisites for maintaining Rivers in efficient working condition, so as to meet our fundamental need of putting the waters to the greatest use in the shortest practicable time, are :—

(1) avoidance of encroachment on flood ways,

(2) reduction in the quantity of debris to be transported by running water, and

(3) maintenance in the dry season of adequate supplies of water through sub-surface drainage, by converting as much of the run-off as practicable into run-in.

Now none of these requisites is such as can be fully met, and it is not surprising therefore to find that there is no panacea for the flood problem.

14. Behind the flood problem lies the solution of the all-embracing question of river control, conservation of water resources, and beneficial development of the full length of a river for the service of the region along its entire course. The consequences involved are vast and the decision is momentous. Such activities, as promoting types of farm and forest management that will largely neutralize the otherwise unavoidable tendency of tillage to increase the fluctuations of stream-flow, provision of wind-brakes and construction of field embankments as protection against onslaughts from erosion, and maintenance of a fewer and better stock are major factors which cannot be ignored in the problem of River Regulation. Our study of the problem leads to the conclusion that soil deterioration inevitably leads to deterioration and decay of rivers.

15. As prevention is better than cure, the first place in the programme for River Training should be given to such precau-

tionary measures for maintaining the river systems in efficient working order. But the need for cure will still remain, and we shall now take up the technical aspects of this subject, which constitute one of the most important problems with which the hydraulic engineer is called upon to deal.

DATA

16. Considering the great number of factors in operation, the collection of a vast amount of data becomes necessary, in order to ascertain in what direction remedial action holds out the best prospects of success. The particulars for determining the magnitude of the interests to be protected having been obtained, the decision as to which form of improvement should be adopted is one that requires a very thorough knowledge of the river and its basin. A topographic survey based on a geodetic framework, to determine the surface conditions of the visible valley, is the primary essential. Hydrological data must be amplified and kept up to date to provide a sound basis for any flood control programme. Information is needed in regard to the extent and water equivalent of the snow-cover, and the condition of the ground beneath the snow. Streams should be gauged and river systems should be examined by thoroughly surveying and levelling them. Flood recorders should be installed at key points, whereby the variation of the surface slope could be recorded automatically. After every exceptionally high flood, a special report should be drawn up giving all observations regarding it. An important record is that of the improvement and deterioration of the rivers and their branches. An accurate knowledge of the physical conditions of a tidal river and its estuary, and also of the tides and currents, is essential to any works being undertaken for its alteration and improvement. No record that may be needed for an intensive study of each basin should be neglected; without this it will not be possible to assess the importance of the various causes. We must know the hydraulics of the rivers, the features which are liable to change, the boundaries of the normal periodic swings of the rivers, the manner in which waves, tides, and currents, affect the breaches on shores, etc.

STUDIES.

17. Neither observed facts alone nor judgment unsupported by experimental observation will lead to a sound solution of flood problems. It can only be reached by the combination of the two. A hydro-technic laboratory is required for the study, on small scale models, of the life of rivers, and no time should be lost in starting one to investigate river problems. There are many complex problems to be studied, and advance will best be made by the application of laboratory experimentation.

18. The reshaping of a river is as much an art as a science, and needs long years of experience of, and experiment with, the river itself. As an instance, we may consider the influence of cut-offs on a river in order to facilitate rapid drainage. No doubt a shortened course reduces flood heights; but nature having established through centuries of time a balance between the material of the bed and the length and slope of the river, it is reasonable to question if the upset of this balance will not generate an effort in the river to restore its former regimen. In a problem like this, mathematical analysis may be of some help; but conviction can only come from model studies.

MEASURES FOR CONTROL OF RIVER FLOODS.

19. Projects for the flood control of rivers fall into two groups: (1) flood prevention and (2) flood protection. The former measures are designed to prevent flood stages, and the latter to prevent damage or to minimise the effects of flood stages. The two methods should be supplementary, and each should be sufficiently flexible to permit of its modification or elaboration, if and when needed, to meet the increased economic development of the protected areas. It is important to remember that, in the general case, the economic set up of a flood control plan must rest on the present values to be protected. The proponents of flood control are prone to advance uncertain eventual benefits of increased exploitation of the resources as a reason for the expenditure of enormous sums of money. It is not possible to justify this policy. A complete flood control system is never planned and executed at a single stroke.

20. **Flood Prevention-Storage Reservoirs:**—The primary cause of river floods is the rapidity with which the rain water or the melting snow finds its way into the rivers. The remedy lies in the detention of water by storage—whether underground, or by the building of surface reservoirs. Rapid run-off can, no doubt to some extent, be counteracted by afforestation and good cultivation, thereby facilitating the percolation of water into the ground, and its consequent storage in subterranean reservoirs; but there are definite limitations to this method and it cannot be accepted as a basic method of flood control. Storage must be provided by means of surface reservoirs, and its function is to hold back water which cannot be passed without flooding, and to control its release in accordance with the discharging capacity of the rivers, as soon as the rivers pass below the flooding point.

21. Storage is the backbone of successful flood operations, and the moderating influence of an artificial reservoir system, like that of the Great Lakes in the basin of the St. Lawrence, has never been questioned. It is the soundest method of flood control, as the works can be constructed and operated with greater

certainty and safety than any other flood work. Storages are now unhesitatingly created on the smaller streams with the object of flood prevention. It is as often the suddenness as the magnitude that causes damage and loss of life, and reservoir action effectively prevents sudden floods.

22. Rivers have to be tamed first, in order that the attempts to train them may be successful. A notable example of the efficacy of storage is that of the Nile. The engineers of the Pharaohs of the 12th dynasty built dikes letting the water into Lake Moeris. As years went by, the river gradually widened and deepened its channel, and the time came when the safeguard of the reservoir was no longer needed. After 2000 years Lake Moeris was reclaimed, and now constitutes the Fayoum Province.

23. There are, of course, limitations to the employment of reservoir storage. There may not always be suitable sites available to permit of the storage of the huge volumes of water required to be held up. It may also be that artificial lakes cannot be formed without serious injury to other interests. If a site is found, its location may be so far upstream that the effect on the area to be protected may be inappreciable, owing to the tributaries being left uncovered. Finally storage works may not eliminate altogether the necessity for lower river protection.

24. It is also evident that complete relief is not possible from reliance upon storage alone. For the mitigation of floods, the best solution will lie in combining reservoir control with improvement of river channels at critical places. Very often rivers are unable to discharge the water brought down in floods, and the designer of engineering works is confronted with many compolicated conditions, especially when there is a low fall. The capacity of the river channels has to be increased; and outlets, lateral canals, and cut-offs may be needed. Action may also have to be taken to prevent the caving of banks and the deposit of sediment in river beds, by recourse to lining the banks and dredging the bed.

25. Storage is a costly undertaking, and the construction of reservoirs for the purpose of flood prevention alone is not a practicable proposition. Where reservoirs have to be constructed for some primary use giving a money return, it becomes feasible to provide the extra capacity required for floods, as the rate cost rapidly diminishes as storage capacity is increased. The problem of water embraces its multiple uses, and the aim of river control cannot be achieved by restricting it to a particular usage. The development of a flood-protection policy should not be separated from that of the national policy governing water resources in general. There are some uses, such as flood protection and navigation, from which a return is not in

sight. Irrigation and water supply give somewhat meagre returns. But within recent years the question of bearing the first cost has come to be modified by the possibilities of power development. The initiation of a programme of storage commensurate with the country's needs will be found to be fully justified.

26. **Flood Protection—Levees:**—Levees are the usual system of defence against floods. The Egyptians and the Babylonians appear to have been the first to employ this method, and one of the earliest examples is found around the city of Babylon. The valleys of the Po, the Tisza, and the lower Mississiphi, have been protected in this way; and Holland is the most impressive example of the successful employment of defensive embankments. The plan of embankments was originally conceived and especially meant for the protection of vested interests—in some cases of great importance. The very condition of the existence of such towns as New Orleans and Srinagar is artificial protection against inundation. Embankments have also to be resorted to for the river training works that may be needed to make particular reaches of rivers stable, or to prevent rivers deteriorating.

27. The urgent need for immediate protection has, however, led to an unfortunate establishment of levee lines, and the disadvantages of incorrect location are perpetuated as the embankments are strengthened and reconstructed. There was little attention paid to the laws of flow, and as a consequence levees present obstructions to floods at critical places. Continuous levees without arrangements for cross drainage are harmful constructions. There are besides circuit embankments enclosing low-lying places, which have become no better than pits, and which can only be emptied by pumping ; while excellent drainage and sewer systems are needed. This haphazard system of embankments is heading towards disastrous results.

28. There is a belief that the confinement of the flood waters within the leveed trough has increased flood heights; that levees should therefore be abandoned and the flood waters allowed to flow over the lands to deposit their silt; that the fertility of an alluvial valley depends upon periodic overflow in its state of nature; and that this system of flood control actually results in damage to agriculture, which may ultimately go far to offset the benefits derived from the occasional saving of crops from flood. The valley of the Lower Nile is referred to as the classic example of the latter state of affairs. There is, however, no clear evidence to show that flood heights are increasing, or that levees have resulted in a raising of the river bed. Existing works in Europe and America do not corroborate this statement. The assumption of the rising of a river bed ignores other agencies which also produce an elevation of the flood plane. The general

effect upon the Mississippi is a tendency to lower its bed, rather than raise it. As for the example of the Nile, it may be pointed out that the Nile floods reach its mouth early in the spring, or before the agriculturist plants his crop—a condition that does not prevail everywhere.

29. The efficacy of levees in contributing to channel improvement is corroborated by experience, though the average rate of this irregular development is extremely slow. The system of levees is perhaps the only method of controlling an alluvial river, and levees will continue to play a dominant part in flood protection. But they alone cannot be relied upon to serve the purpose. The plan of embankments was subjected to an abstruse analysis in America and was, for a time, given prominence. The long held doctrine has now been thrown overboard, and the "levees only" theory may be said to have been officially abandoned. Levees must have help, and the only promising help is reservoir control.

30. **TIDAL RIVERS** :— Space does not permit us to deal adequately with the measures called for in the lowest or the tidal regions of rivers. The physical characteristics are so diverse that no attempt can be made to dogmatize on the best means of improving the outfall: the range of tide may be limited, there may be an estuary to afford some protection, or the outfall may be directly into oceans subject to violent storms, severe tidal effects, etc. Many forces are at work, and usually fresh water alone is powerless to maintain a sea outlet. There is a struggle between the waves and the currents tending to form bars. There may be raising of the sea bed, and even a variation in the level of the sea owing to the heading of water during the monsoons. It is evident that an exhaustive inquiry will need to be made into the problems of each inefficient outlet.

31. It is not impossible to assist nature in her efforts to discharge the water of rivers into the sea; but the expense involved is great, and is usually justifiable only where navigation is a matter of practical importance. Where this is not the case, and the root of the troubles is premature reclamation of land, there may not be sufficient reason for the undertaking of ambitious projects, and the remedy lies principally in throwing open the spill areas for the rivers. Flooding is nature's method of land formation, and there must be no hindrance to the free passage of floods by tidal obstructions. At the mouths of rivers, embankments can hardly be viewed as a means of protection: they only aggravate flooding and lead to destruction of the country in the vicinity.

Reclamation should be stopped, and facilities provided for the rehabilitation of the people. A careful local investigation

will enable a number of subsidiary measures to be suggested which will ameliorate the conditions, but the chief remedy will be found to lie in the removal of obstacles to the working of nature.

32. There are situations, however, where the damage caused has to be seriously recognised. The problem of the Orissa Delta is of such a nature. Not having visited this area we have no personal knowledge, and we can only make a few general observations based upon the information contained in the Report of the Orissa Flood Committee, 1928. Among the intricate complications in this delta there are two features of major importance-(1) the shortness of the delta, and (2) the number of rivers the mouths of which join here. The waters of the Mahanadi, the Brahmini, and the Baitarani find their way to the sea through this strip of deltaic country.

Fortunately nature seems to have provided two great facilities here—one, in the existence of good reservoir sites not very distant from the area to be protected, and the other, in the possibility of the diversion of the river waters into the Chilka Lake. The Committee concluded that a solution through these means is not practicable . We recognise the great thought and labour the Committee have devoted to their Report, but we are forced to state that we cannot find that they have based their warnings on any such facts as could unhesitatingly be accepted. The nature of the basin does not seem to be such as to make the reservoir system inapplicable. Indeed it is possible that the greatest prospects of finality and success would lie in the direction of provision of storage and of escaping a part of the waters through the Chilka Lake into the sea. The work is of a straightforward character, and there need be no apprehensions in regard to it. The harnessing of the rivers to the service of irrigation and power is an eminently desirable aim, and a remunerative return might be contemplated. In a case of such far-reaching importance it is desirable that every possible alternative should be closely and exhaustively investigated.

It is important to unite all the rivers of this tract into one main trunk and not allow them to run off into several small channels. The whole force of the tidal and fresh water currents should be concentrated in maintaining a deep uniform channel which should be pushed out by means of training walls as far as possible. The river should be allowed to lengthen itself: a long length of tidal run up a deep and defined course is of greater value than tidal area in an estuary.

THE REQUISITES OF FLOOD CONTROL PLANNING CONCLUSION

33. The preparation of a plan for the control of floods involves an intensive study of the river system for the selection of a method or combination of methods to be employed. The plan must be based on sound principles of river engineering; it should be simple, and, as far as possible, automatic in its operation. It must also be economically sound, i.e., it must secure the maximum benefits to the protected areas commensurate with the costs of the construction and maintenance of the works. There should be the aggregate balance of immediate advantages in favour of the undertaking. It must be remembered that there is no direct return from flood works, and that the benefit or loss is national rather than personal.

34. A matter of paramount importance which should receive early attention is the organising of a flood forecasting and warning service. The full value of flood control works will only be obtained with the maximum foreknowledge of expected floods. A weather bureau should be set up; and arrangements should be made for additional gauging stations at strategic points in the river basins to assist in operating the flood control reservoirs.

35. For taking systematic and effective steps in the nature of remedial measures, some Statutory Authority, on the lines of the Tennessee Valley Authority, should be established. The Authority will take on almost a governmental character, and an important function to be assigned to it is the persuasion, by advancing rehabilitation loans, of the people living in the low parts of valleys to remove to higher ground. Appropriations for flood protection are as essential for the general welfare as appropriations for famine relief. Flood control should form a federal subject, as is appreciated by the Americans, and not left to individual States. The problem embraces river training, conservation of water, and beneficial development of the rivers for their entire lengths; and it involves many highly complex engineering questions as well as those of governmental relations between the States interested in the waters. The planning of works has to be for the manifold uses of water, and there may appear to be a conflict between the different activities; but in most cases such conflicts can be harmonized with little loss of efficiency.

PART III

Report

on

WATER POWER EXPLOITATION

by

NAWAB ALI NAWAZ JUNG BAHADUR
F. C. H.

REPORT ON WATER POWER EXPLOITATION.

1. **INTRODUCTORY** :— The utilisation of the natural resources for generation of power through such contrivances as the sail, the wind-mill, the water mill, scoop wheel, etc. is as old as the hills. Even the ancients must have realised that power is the main factor in the equation of labour. When we reduce the human and the material resources necessary to produce energy, we augment the potential amount of consumable goods available for the community. Today cheap power, as the vital force behind industrial development, is one of the important solutions of the economic problems. Along with food, clothing and water, power is an essential need of life, and we must achieve a larger use of it by carrying it to more consumers. Water power exploitation developed *puri passu* with colonisation of the land, and the use of water wheels can be traced back to the Middle Ages. The original method of utilising water power by means of wheels is still pursued in the grain mills, agricultural enterprises and the wood working industries, and also in the small forges and stamping mills of the iron, steel and metal manufacturing industries.

2. In the 18th Century, Euler established the primary laws of Hydraulics, and improvements quickly followed. But 'turbine', as designation for a horizontal wheel, came in 1824; and even then the hydraulic turbine possessed no real vitality till the period 1885 to 1914. It is only after the commencement of the Great War that we find large turbines constructed with high speed runners; and the progress of structural engineering has kept pace with the development of the water-power machine. The discovery of the steam-engine by James Watt about the close of the 18th Century., and the advent of electricity early in the 19th Century, accelerated the progress of the Industrial Revolution. In 1866 the self-exited dynamo came into existence, and it laid the foundation of heavy-current electrical engineering as we know it today. Engineering was placed in possession of the means to enable electric energy to be generated cheaply in large quantities, wherever the necessary motive power was available. The electric dynamo soon proceeded to carry things before it. From exploding mines, its use was extended in 1877 for electro-chemical purposes.

3. At the same time, the development of long distance transmission provided the key to the release of the power from hydraulic undertakings for useful work, by widening the radius of application. The history of this progress is remarkable. In the early days of the development of the incandescent lamp, mathematical demonstration was given to the effect that it

would not be economically feasible to take power to such lamps for a distance greater than a few hundred feet. The proposition held good for the conditions then existing. The three-wire system and the 100 volt lamp, however, upset both the assumptions and the conclusion; and power was transmitted to lamps several thousand feet away. Then, with the advent of the alternating current and its use, the transformer became known; and it was demonstrated that it would be commercially impracticable for power to be carried more than a few miles. But the improvements in construction invalidated this assertion also. Power is now carried to a distance of over 300 miles at a pressure as high as 150 kilo-volts or more; and the whole mechanism of generation and distribution can be supervised from a central point.

4. **Importance of the Energy of Natural Resources :—** The out-put of work per person in India is very low at present. It probably does not exceed 100 units, of which about 60 represents human labour, 15 animal labour, and 25 energy from mechanical sources. Of this last, electricity, which is the most suitable form of power, accounts for perhaps 8 units. When it is remembered that power is at the root of our modern-day industrial organisation, and that comparison between the indices of electricity production and the earning capacity of the people reflects the economic prosperity of a country, the great backwardness of India is evident. Modern nations expend far more energy than the combined muscular ability of their populations and beasts of burden; and their much larger out-put arises from the use of machinery and artificial motive power for production. Supply of power is the measure for ascertaining the level of the production forces and the trend of technological development.

5. The lessening of toil and obtaining of comforts and enjoyments are possible in no other way than through greater utilisation of energy. Cheap mechanical energy increases the demand for supervisory and other forms of what may be termed mental labour, permitting men and women to enter occupations of the human-service type. Any success, therefore, in the economic up-building of the country, and in raising the welfare of the inhabitants would depend in large measure on the use we make of the energies of nature in the service of man. India at present is a granary of raw materials, and there is a great prospect for power through industry. We know that we are abundantly endowed with natural energies, and that a steady and an adequate supply of power to various industrial concerns is normally an income producing undertaking. The density of population is increasing; and with it grows the necessity for carefully and economically developing our resources. Only by wisely employing them, can the burden on the masses be lifted, setting free their creative ability.

6. **The Various Resources and their Characteristics :—** For a properly planned development to be brought about, it is necessary to examine the characteristics of the major resources. These characteristics are broadly as under :—

(a) The power sources are numerous, but many of them we may leave out of consideration here. Solar and wave power do not at present appear to be economic, liquid fuel and natural gas are scanty in India, and wind can only be used to a very small extent.

(b) The mineral resources have required geological time for their accumulation. They are irreplaceable sources of energy, and their utilisation, even should it be without any waste, must of necessity diminish the store available for posterity. Their exploitation is equivalent to living on the country's capital resources.

(c) Forests are replaceable, but at a slow rate; and their utilisation diminishes the store available for our immediate successors; we shall be heading towards exhaustion of these reserves if we use them indiscriminately.

(d) While the above two kinds are material resources, which get consumed in the process of power generation, our third resource, viz: water-power, falls under a different category. Here we are merely utilising the gravity of water without consuming any substance; and, if we do not put this resource to use, we are not storing and preserving, we are merely wasting it.

This summary, though brief, should affect our attitude towards water-power enterprises. The available supply of our various resources is at present far in excess of our needs, and there is the danger, therefore, of our not taking steps to preserve them for future generations, or of not properly utilising and causing waste. The resources must be conserved, i.e. they must be utilised with a maximum efficiency and a minimum of waste. It is not in the power of man to arrest the demand, but it is within his province to suggest processes by which decay may be arrested in degree. When we view things in this light, the importance of water-power becomes mainfest. The harnessing of falling water does not involve the depletion of resources, and this being so, instead of restriction, the greatest possible use is called for. Water-power is a perpetual mine, and every horse-power generated hydraulically represents an annual saving of approximately 4 tons of coal; while any use whatsoever of water-power is better than no use at all.

7. Besides, those resources of ours, which are of the material kind, are not widely distributed, are limited in quantity, and are generally not of superior quality. The important material resource, viz: coal, is to be found in fairly well-defined zones, and the economics of developing hydro-power in competition with it need not worry us much. Water-power is not likely to replace steam altogether—even in America where it has been harnessed to an extent unequalled anywhere. It is, however, a diminishing asset, and it is necessary to reserve it for purposes that require and must use thermal power, such as hydrogenation to liquid fuel, for blending etc. It is also one of the important raw materials for synthetic chemical industries. The question is not just one of duration, but as to how long the better and more cheaply got coals will last. Not only is the reservation of our material resources an important consideration, but there is reason to think that, at the present moment, we are not getting the most out of them. The thermal efficiency of steam engines has increased in modern days from about 18% to 36%, and it is quite possible that it may go still higher: quite recently i.e. in 1932, a unit was being generated for about 0.45 anna, excluding fixed charges and depreciation, while the equivalent cost is now expected to be 0.28 anna per unit. On the other hand with much larger efficiency, the margin for possible improvements due to advances in engneering science is very small in the case of a water plant.

8. It is not difficult to understand why, in the past, the use of fuel assumed great prominence. Under the old conditions the superiority of thermal power to hydro-power was so marked that a small fraction of the water-power, viz: that which could be easily developed, was commercially available. A thermal power station could be placed in the most favourable site, while the hydraulic plant had to be where nature placed it. A water-power far from the point of use, was practically useless: in general it was cheaper to transport coal than to transmit energy above a certain distance. Another consideration is that the hydro-electric plant does not possess as much flexibility as regards load factor as the steam plant. The conditions have radically changed, since electricity was found to be the most adaptable of power. The question now is not one of merely supplying a few concentrated loads in the most favourable sites, but of supplying the whole countryside; and this view has come about by the progress made in the realm of electricity, in so far as transmission over long distances is concerned. The transport of electricity is cheaper than the transport of coal, when the distance is not much larger than 100 miles. In the vast majority of cases, with fuel located in restricted areas, it will be folly to continue its use for this purpose after transportation over great disances. With the postulated larger and wider use,

the scales are turned for the employment of falling water; and we can now live on the nation's annual income, without encroaching to a serious extent on her capital. The water-power utilised electrically represents an ever-increasing percentage of the total utilised water-power: in Sweden it was 66% in 1914 and 91% in 1933.

9. **Hydro-Power.** From the point of view of conservation, it is far better for the people that water power should be used instead of calorific energy, at the same or even a somewhat greater cost. By careful planning, a considerable amount of imported oil and also coal, now used for power purposes, could be replaced by the gravity of power. Our coal supplies must not be indiscriminately exploited, and power producers will in future have to look more to the natural forces that do not give out. With bad load factors and cheap, coal, no water power can, of course, compete; but rural electrification, and industries utilising electro-chemical or electro-physical processes, which require a large amount of cheap power, will get ruled out unless water power is developed. With water power, the advantage increases as the load factor rises, and any sales which fill up the hollows in the load curve without affecting the peak are profitable at whatever rate they bring in. Efforts are being made, where water powers are available, to utilise them to a continuously greater extent, particularly in countries which have to import coal for the production of energy. In Sweden hydro-energy generally accounts for about 92% of the total output, the rest being generated by thermal plants. With this source developed, distributed, and sold at low cost, a decided betterment can be effected in the standard of living by its wide-spread use in the homes and on the farms. Moreover, coal mining is a dirty and disagreeable job; and hydro-plant, with its cleanliness and comparative ease in operation and maintenance, will be able to put up a strong challenge.

10. There are great losses in fuel and in other resources, while our waters, instead of being utilised, are allowed to go waste, and to cause destruction where they should be of service. Every cultured nation has realised the importance of developing and exploiting the water power, and the tremendous hydraulic power plants are witness to this development, which is destined to revive and promote industry and commerce, and which is able to create new bases of existence. The trend in this direction has permitted the construction of works which represent considerable national assets and excellent opportunities of reducing unemployment and preventing the drift of rural population into the cities. To a country that is mainly agricultural, a well planned hydro-electric scheme brings with it many indirect benefits which are not present in the alternative methods of

generating power. The provision of water cannot, however, be regarded as merely a measure for the production of power; and it is hoped that there will be no such struggle between economic and social policies as would involve the letting down of unused water made available by storage at great expense. Irrigation and power have come into the position of joint enterprise, and are expected to support each other, thereby giving rise to a radical change in the situation. The large item of cost, viz: that for provision of storage, does not become a burden when it is distributed over the multiple uses to which water can be put. A favourable prospect for the absorption of water and its gravity can generally be secured, even if either be regarded as doubtful and costly. In any evnt, the original scheme extended by a second project creates an economic basis for the whole undertaking. The possibility of utilising flood supplies for seasonal operations in connection with mining, agriculture and forestry, or the production of nitrates, is also worthy of consideration.

11. Hydro-electric development possesses certain definite advantages. Every horse power that can be developed by water, preserves Rs. 40|- worth of coal per annum and would justify an investment of Rs. 400|- in a water-power plant in excess of a steam plant. In general the dependablity of hydro-electric generating units is greater than that of heat units, because of the fact that the former operate at comparatively low speed and at ordinary temperatures, whereas heat units require high speed and high temperature. The non-scheduled voltage "when in demand" is negligible and hydro-plant units can be placed in operation quickly (in a few minutes), which is important and valuable under sudden large load increases and emegencies. There is also less power required for station service than in a steam plant, which needs energy for operating cooling water pumps, boiler feed water pumps, coal-handling equipment etc. Further first-class hydro-electric machinery is so reliable in operation and is subject to so few stoppages for inspection and maintenance that the provision for spare plant can be made very small. The cost of developing a hydro-electric scheme is, no doubt, usually greater than the simple erection of a thermal power station. But against this, there are substantial savings in running expenses. The ratio of fixed charges varies between 7 and 11 per cent water-power, whereas it is 11 to 15 per cent for steam power. The average rate of depreciation will be as low as 2% for a hydro-plant, while it may be as high as 5% for a steam plant: the life expectancy of a hydro-plant is very much greater than that of a steam manufacturing station. It must also be remembered that prices of coal are continually rising and that the additional capacity for the steam plant with reference to its sysem peak use is relatively high in cost. In countries

where water power resources have been developed on an extensive scale, the effect on local consumption is important: the consumption of electricity per capita is markedly higher than in other countries, on account of the advantageous terms for sale. The output per head, for instance, in Norway, mostly hydro, is 1800 units.

12. As a rule the development of hydro-power is indispensable, and we may brifely sum up the situation in this way:- The only way to increase prosperity is to increase the output of power per head. The best cure for low wages is motive power. The most economical means of applying power to industry is the electric motor. The position of a country in the scale of modern civilisation can best be gauged by the amount of electrical power per head made available for the benefit of its toiling humanity. Finally, the form of prime mover for generating power which holds out the greatest promise of social success is the gravity of water.

13. It is necessary to present the other side of the case as well. Because of the large first cost of water power developments, there is the corresponding risk of loss which makes capital shy to go in for these undertakings to any considerable degrees. Another disadvantage is that the demand must be foreseen a long time in advance, and the installation made for a greater capacity than the existing market needs. Then the technical difficulties are more involved, owing to the larger scale of operations. The history of water power enterprises is not by any means a history of unbroken successful effort. It is strewn with wrecks, and there is no industrial field in which a sound engineering preliminary judgment would seem to be more necessary. The technical difficulties of locating and then of building suitable works for harnessing the power must not be discounted: to overcome them may not infrequently prove a fantastic dream. Further, long-distance transmission is uneconomical and it will be necessary to move cautiously: the cost of tranmission lines operates detrimentally by increasing the prime cost and decreasing the energy available for sale.

14. **Fuel-Hydro Combination:-** We have said that water power in this country should be regarded as a by-product of irrigation: the supply of water is also subject to great variations. Its development consequently is not feasible to any large extent, unless it can be in combination with another power source. Where the output is supplemented by thermal engine reserves, the stability and the economic value are greatly increased. In a system served by water power, the utilisation factor may be between 30 and 60 per cent: when such a plant is connected with a steam system, the utilisation factor may exceed 90%. This idea of combination, in the large sense of having the

regime of the two sources complementary, is modern, and it has established the pronounced superiority of hydro-power. There is of course a certain amount of competition, and the main difficulty lies in the fact that power can be developed in general only when a market is already established, i.e., for communities where steam is being used. A considerable co-operation, has, however, been brought about, with a view to achieve planning, reliability of service, and sound economy: and a fuel-hydro combination generally results in a very flexible power station which will be superior to, and more economical than, either scheme taken separately.

What should be constantly kept in mind is to encourage the greatest possible development, and to ensure this development in a manner consistent with the interests of the people; and, in this connection, it may be noted that the energy production of the uncombined water power station can seldom be fully utilised. Steam stations may have to be erected for the gradual building up of the demand in the early stages and will be requisitioned for conversion of secondary into primary power; and their addition will be found to be economically justified when the demand for power exceeds the base capacity of the hydro-electric plant. Even Niagara Falls cannot be fully put to use, except as a part of a large system havng a substantial amount of steam power, since loads requiring constant outputs are rare. Niagara, 'tied in' with steam power, can carry a large base load, and then it can be fully utilised. The economic ratio between hydro and steam power will depend mainly on the characteristics of the demand as development proceeds, and the cost of generation by steam. Recently in the Province of Madras, a close study was made of the problem at Papanasam, and it indicated that ultimately the cost of producion from the hydro-fuel combination was less than that by hydro or by steam alone.

15. Collaboration with steam appears to afford the best solution of one of the most important factors of modern energy economics, viz: the demand for the maximum possible regularity in the energy supply of the large and diverse consumer routes connected to the system. With the combination, the firm capacity of hydro plant is looked upon in an entirely different way; it is now possible to use all the power that can be developed in such a manner that the distinction between firm and secondary power may be said to exist no longer. The inter-connection will permit of hydro-power during the high water season to be transmitted one way, and the requisite thermal power during times of low water discharge the other way. Even if an electricity system cannot be built up solely by means of water power, the latter provides a valuable suppliment for steam power.

16. Normally water power stations are operated as base

load plants, and generate as much of the power as can be utilised by the system served with a load factor of say 60% or over, and steam plants are run at a very low load factor, so as to save fuel. This is so because in a water power plant it costs practically the same for generation, whether one-quarter of the output is delivered or the whole; it makes little difference what proportion of the full supply is carried—some perhaps, but not worth considering. The result is that the more uniform load is carried by water power for about 85% of the time, and by steam plants 15% of the time. In regard to the average energy generated, the ratio of k. w. h. by water power to that of fuel power would generally be 4 :1. This is sometimes expressed by saying that water power looks after energy (measured in k. w. h.), and steam is to look after the load measured in kilowatts. The position is reversed during seasons of low discharge and in years of deficient supply: the water power stations serve the requirements of the upper part of the load curve, the steam parts carrying the basic portion of it. It is interesting to note here that in countries like Sweden, where hydro-electric power has by no means lost its preponderance, the annual increase of the thermal capacity in recent years has been remarkable and compares with that of the hydro-capacity. Most of this, no doubt, is to be found in stand-by plants to hydro-electric stations. Nevertheless it goes to establish the pre-requisite that a hydro-electric scheme should possess all the elements of a successful undertaking which operated in conjuction with steam plants, could meet the growing demand in an economic and satisfactory manner. It is only then that it will give promise of the greatest social progress.

17. Modern industry requires permanency in its water supply so that it can budget its production; whereas no water power plant attempts to use the maximum flow, and not many attempt to use more than the flow for 8 or 9 months. There is also the subordination to irrigation interests. A hydro-power scheme cannot therefore be regarded as a self-contained project, and there is a manifest advantage in linking up with another source. There are many points in favour of this. For instance, if a bomb were dropped by an enemy on a fuel station located in an important market centre it would paralyse all business seriously: whereas damage to an electrical transmission line could be set right in a short time. Again, hydro-power service is liable to many an interruption causing inconvenience, while somewhat disastrous consequences may occur when too great a reliance is placed on fuel power service, owing to the duration of interruption being longer.

18. **Important Aspects of Hydro-Power Development.** The development of electrical transmission has greatly increased the

availability of water power. With its long transmission lines, water power will enable a large circle of consumers to be supplied without proportionately greater expenses being incurred; and, wherever feasible, a wide ramification of electric service mains should be undertaken in the countryside in order to supply power to agriculturists and for village needs. It must be remembered that the creation of greater abundance in the use of the natural energies is dependent not so much on scientific and engineering achievements as on suitably organising our affairs. Water power has a value which we cannot afford to neglect, and the combination of its interests with those of agriculture will provide the most economical method of securing the improvement of our rivers. The advantage of hydro-power increases with a well-sustained load; and, it is more economical to transmit power at a high load factor than a low one.

19. An interesting problem is the combination of water powers situated in different localities. A constant interchange is needed to conform to the load and the water conditions, and the advantage of linking up sources of power in different watersheds is great. The generating stations can then be operated to the best advantage, and the economic value is considerably increased. Regarded individually the potential power output of a station would be variable, but conjoint working produces a favourable situation. The best and most satisfactory use of water will only be secured when the flow can be regulated according to the demand; and, as large storages may not always be practicable in each of the different watersheds, the inherent disadvantege of unsteadiness in supply has to be met by linking up.

20. It has also to be noted that to obtain full advantage of the power possibilities of the rivers, the programme of their development should be carried forward over a period of years in such a way that new power units may be brought into service progressively as required, without undue increase in the investments at any one time: capital charges remaining unproductive for years should be avoided, and data of a speculative character should be excluded. The pace of the programme will be determined by the consideration that power is usually developed as a corollary of the irrigation or the navigation works; and slow progress under these might bring about a condition of stagnation.

21. The much-discussed problem of dealing with the continually increasing peak loads, in a rationally satisfactory manner, can be solved by adopting the principle of accumulating water in an elevated upper reservoir by means of pumping, and creating a power storage station. Pumped storage enables the wastage current of hydro or thermal power stations to put

6. **The Various Resources and their Characteristics :—** For a properly planned development to be brought about, it is necessary to examine the characteristics of the major resources. These characteristics are broadly as under :—

(a) The power sources are numerous, but many of them we may leave out of consideration here. Solar and wave power do not at present appear to be economic, liquid fuel and natural gas are scanty in India, and wind can only be used to a very small extent.

(b) The mineral resources have required geological time for their accumulation. They are irreplaceable sources of energy, and their utilisation, even should it be without any waste, must of necessity diminish the store available for posterity. Their exploitation is equivalent to living on the country's capital resources.

(c) Forests are replaceable, but at a slow rate; and their utilisation diminishes the store available for our immediate successors; we shall be heading towards exhaustion of these reserves if we use them indiscriminately.

(d) While the above two kinds are material resources, which get consumed in the process of power generation, our third resource, viz: water-power, falls under a different category. Here we are merely utilising the gravity of water without consuming any substance; and, if we do not put this resource to use, we are not storing and preserving, we are merely wasting it.

This summary, though brief, should affect our attitude towards water-power enterprises. The available supply of our various resources is at present far in excess of our needs, and there is the danger, therefore, of our not taking steps to preserve them for future generations, or of not properly utilising and causing waste. The resources must be conserved, i.e. they must be utilised with a maximum efficiency and a minimum of waste. It is not in the power of man to arrest the demand, but it is within his province to suggest processes by which decay may be arrested in degree. When we view things in this light, the importance of water-power becomes mainfest. The harnessing of falling water does not involve the depletion of resources, and this being so, instead of restriction, the greatest possible use is called for. Water-power is a perpetual mine, and every horse-power generated hydraulically represents an annual saving of approximately 4 tons of coal; while any use whatsoever of water-power is better than no use at all.

7. Besides, those resources of ours, which are of the material kind, are not widely distributed, are limited in quantity, and are generally not of superior quality. The important material resource, viz: coal, is to be found in fairly well-defined zones, and the economics of developing hydro-power in competition with it need not worry us much. Water-power is not likely to replace steam altogether—even in America where it has been harnessed to an extent unequalled anywhere. It is, however, a diminishing asset, and it is necessary to reserve it for purposes that require and must use thermal power, such as hydrogenation to liquid fuel, for blending etc. It is also one of the important raw materials for synthetic chemical industries. The question is not just one of duration, but as to how long the better and more cheaply got coals will last. Not only is the reservation of our material resources an important consideration, but there is reason to think that, at the present moment, we are not getting the most out of them. The thermal efficiency of steam engines has increased in modern days from about 18% to 36%, and it is quite possible that it may go still higher: quite recently i.e. in 1932, a unit was being generated for about 0.45 anna, excluding fixed charges and depreciation, while the equivalent cost is now expected to be 0.28 anna per unit. On the other hand with much larger efficiency, the margin for possible improvements due to advances in engneering science is very small in the case of a water plant.

8. It is not difficult to understand why, in the past, the use of fuel assumed great prominence. Under the old conditions the superiority of thermal power to hydro-power was so marked that a small fraction of the water-power, viz: that which could be easily developed, was commercially available. A thermal power station could be placed in the most favourable site, while the hydraulic plant had to be where nature placed it. A water-power far from the point of use, was practically useless: in general it was cheaper to transport coal than to transmit energy above a certain distance. Another consideration is that the hydro-electric plant does not possess as much flexibility as regards load factor as the steam plant. The conditions have radically changed, since electricity was found to be the most adaptable of power. The question now is not one of merely supplying a few concentrated loads in the most favourable sites, but of supplying the whole countryside; and this view has come about by the progress made in the realm of electricity, in so far as transmission over long distances is concerned. The transport of electricity is cheaper than the transport of coal, when the distance is not much larger than 100 miles. In the vast majority of cases, with fuel located in restricted areas, it will be folly to continue its use for this purpose after transportation over great disances. With the postulated larger and wider use,

the scales are turned for the employment of falling water; and we can now live on the nation's annual income, without encroaching to a serious extent on her capital. The water-power utilised electrically represents an ever-increasing percentage of the total utilised water-power: in Sweden it was 66% in 1914 and 91% in 1933.

9. **Hydro-Power.** From the point of view of conservation, it is far better for the people that water power should be used instead of calorific energy, at the same or even a somewhat greater cost. By careful planning, a considerable amount of imported oil and also coal, now used for power purposes, could be replaced by the gravity of power. Our coal supplies must not be indiscriminately exploited, and power producers will in future have to look more to the natural forces that do not give out. With bad load factors and cheap, coal, no water power can, of course, compete; but rural electrification, and industries utilising electro-chemical or electro-physical processes, which require a large amount of cheap power, will get ruled out unless water power is developed. With water power, the advantage increases as the load factor rises, and any sales which fill up the hollows in the load curve without affecting the peak are profitable at whatever rate they bring in. Efforts are being made, where water powers are available, to utilise them to a continuously greater extent, particularly in countries which have to import coal for the production of energy. In Sweden hydro-energy generally accounts for about 92% of the total output, the rest being generated by thermal plants. With this source developed, distributed, and sold at low cost, a decided betterment can be effected in the standard of living by its wide-spread use in the homes and on the farms. Moreover, coal mining is a dirty and disagreeable job; and hydro-plant, with its cleanliness and comparative ease in operation and maintenance, will be able to put up a strong challenge.

10. There are great losses in fuel and in other resources, while our waters, instead of being utilised, are allowed to go waste, and to cause destruction where they should be of service. Every cultured nation has realised the importance of developing and exploiting the water power, and the tremendous hydraulic power plants are witness to this development, which is destined to revive and promote industry and commerce, and which is able to create new bases of existence. The trend in this direction has permitted the construction of works which represent considerable national assets and excellent opportunities of reducing unemployment and preventing the drift of rural population into the cities. To a country that is mainly agricultural, a well planned hydro-electric scheme brings with it many indirect benefits which are not present in the alternative methods of

generating power. The provision of water cannot, however, be regarded as merely a measure for the production of power; and it is hoped that there will be no such struggle between economic and social policies as would involve the letting down of unused water made available by storage at great expense. Irrigation and power have come into the position of joint enterprise, and are expected to support each other, thereby giving rise to a radical change in the situation. The large item of cost, viz: that for provision of storage, does not become a burden when it is distributed over the multiple uses to which water can be put. A favourable prospect for the absorption of water and its gravity can generally be secured, even if either be regarded as doubtful and costly. In any evnt, the original scheme extended by a second project creates an economic basis for the whole undertaking. The possibility of utilising flood supplies for seasonal operations in connection with mining, agriculture and forestry, or the production of nitrates, is also worthy of consideration.

11. Hydro-electric development possesses certain definite advantages. Every horse power that can be developed by water, preserves Rs. 40|- worth of coal per annum and would justify an investment of Rs. 400|- in a water-power plant in excess of a steam plant. In general the dependablity of hydro-electric generating units is greater than that of heat units, because of the fact that the former operate at comparatively low speed and at ordinary temperatures, whereas heat units require high speed and high temperature. The non-scheduled voltage "when in demand" is negligible and hydro-plant units can be placed in operation quickly (in a few minutes), which is important and valuable under sudden large load increases and emegencies. There is also less power required for station service than in a steam plant, which needs energy for operating cooling water pumps, boiler feed water pumps, coal-handling equipment etc. Further first-class hydro-electric machinery is so reliable in operation and is subject to so few stoppages for inspection and maintenance that the provision for spare plant can be made very small. The cost of developing a hydro-electric scheme is, no doubt, usually greater than the simple erection of a thermal power station. But against this, there are substantial savings in running expenses. The ratio of fixed charges varies between 7 and 11 per cent water-power, whereas it is 11 to 15 per cent for steam power. The average rate of depreciation will be as low as 2% for a hydro-plant, while it may be as high as 5% for a steam plant: the life expectancy of a hydro-plant is very much greater than that of a steam manufacturing station. It must also be remembered that prices of coal are continually rising and that the additional capacity for the steam plant with reference to its sysem peak use is relatively high in cost. In countries

where water power resources have been developed on an extensive scale, the effect on local consumption is important: the consumption of electricity per capita is markedly higher than in other countries, on account of the advantageous terms for sale. The output per head, for instance, in Norway, mostly hydro, is 1800 units.

12. As a rule the development of hydro-power is indispensable, and we may brifely sum up the situation in this way:- The only way to increase prosperity is to increase the output of power per head. The best cure for low wages is motive power. The most economical means of applying power to industry is the electric motor. The position of a country in the scale of modern civilisation can best be gauged by the amount of electrical power per head made available for the benefit of its toiling humanity. Finally, the form of prime mover for generating power which holds out the greatest promise of social success is the gravity of water.

13. It is necessary to present the other side of the case as well. Because of the large first cost of water power developments, there is the corresponding risk of loss which makes capital shy to go in for these undertakings to any considerable degrees. Another disadvantage is that the demand must be foreseen a long time in advance, and the installation made for a greater capacity than the existing market needs. Then the technical difficulties are more involved, owing to the larger scale of operations. The history of water power enterprises is not by any means a history of unbroken successful effort. It is strewn with wrecks, and there is no industrial field in which a sound engineering preliminary judgment would seem to be more necessary. The technical difficulties of locating and then of building suitable works for harnessing the power must not be discounted: to overcome them may not infrequently prove a fantastic dream. Further, long-distance transmission is uneconomical and it will be necessary to move cautiously: the cost of tranmission lines operates detrimentally by increasing the prime cost and decreasing the energy available for sale.

14. **Fuel-Hydro Combination:-** We have said that water power in this country should be regarded as a by-product of irrigation: the supply of water is also subject to great variations. Its development consequently is not feasible to any large extent, unless it can be in combination with another power source. Where the output is supplemented by thermal engine reserves, the stability and the economic value are greatly increased. In a system served by water power, the utilisation factor may be between 30 and 60 per cent: when such a plant is connected with a steam system, the utilisation factor may exceed 90%. This idea of combination, in the large sense of having the

regime of the two sources complementary, is modern, and it has established the pronounced superiority of hydro-power. There is of course a certain amount of competition, and the main difficulty lies in the fact that power can be developed in general only when a market is already established, i.e., for communities where steam is being used. A considerable co-operation, has, however, been brought about, with a view to achieve planning, reliability of service, and sound economy: and a fuel-hydro combination generally results in a very flexible power station which will be superior to, and more economical than, either scheme taken separately.

What should be constantly kept in mind is to encourage the greatest possible development, and to ensure this development in a manner consistent with the interests of the people; and, in this connection, it may be noted that the energy production of the uncombined water power station can seldom be fully utilised. Steam stations may have to be erected for the gradual building up of the demand in the early stages and will be requisitioned for conversion of secondary into primary power; and their addition will be found to be economically justified when the demand for power exceeds the base capacity of the hydro-electric plant. Even Niagara Falls cannot be fully put to use, except as a part of a large system havng a substantial amount of steam power, since loads requiring constant outputs are rare. Niagara, 'tied in' with steam power, can carry a large base load, and then it can be fully utilised. The economic ratio between hydro and steam power will depend mainly on the characteristics of the demand as development proceeds, and the cost of generation by steam. Recently in the Province of Madras, a close study was made of the problem at Papanasam, and it indicated that ultimately the cost of producion from the hydro-fuel combination was less than that by hydro or by steam alone.

15. Collaboration with steam appears to afford the best solution of one of the most important factors of modern energy economics, viz: the demand for the maximum possible regularity in the energy supply of the large and diverse consumer routes connected to the system. With the combination, the firm capacity of hydro plant is looked upon in an entirely different way; it is now possible to use all the power that can be developed in such a manner that the distinction between firm and secondary power may be said to exist no longer. The inter-connection will permit of hydro-power during the high water season to be transmitted one way, and the requisite thermal power during times of low water discharge the other way. Even if an electricity system cannot be built up solely by means of water power, the latter provides a valuable suppliment for steam power.

16. Normally water power stations are operated as base

load plants, and generate as much of the power as can be utilised by the system served with a load factor of say 60% or over, and steam plants are run at a very low load factor, so as to save fuel. This is so because in a water power plant it costs practically the same for generation, whether one-quarter of the output is delivered or the whole; it makes little difference what proportion of the full supply is carried—some perhaps, but not worth considering. The result is that the more uniform load is carried by water power for about 85% of the time, and by steam plants 15% of the time. In regard to the average energy generated, the ratio of k. w. h. by water power to that of fuel power would generally be 4 :1. This is sometimes expressed by saying that water power looks after energy (measured in k. w. h.), and steam is to look after the load measured in kilowatts. The position is reversed during seasons of low discharge and in years of deficient supply: the water power stations serve the requirements of the upper part of the load curve, the steam parts carrying the basic portion of it. It is interesting to note here that in countries like Sweden, where hydro-electric power has by no means lost its preponderance, the annual increase of the thermal capacity in recent years has been remarkable and compares with that of the hydro-capacity. Most of this, no doubt, is to be found in stand-by plants to hydro-electric stations. Nevertheless it goes to establish the pre-requisite that a hydro-electric scheme should possess all the elements of a successful undertaking which operated in conjuction with steam plants, could meet the growing demand in an economic and satisfactory manner. It is only then that it will give promise of the greatest social progress.

17. Modern industry requires permanency in its water supply so that it can budget its production; whereas no water power plant attempts to use the maximum flow, and not many attempt to use more than the flow for 8 or 9 months. There is also the subordination to irrigation interests. A hydro-power scheme cannot therefore be regarded as a self-contained project, and there is a manifest advantage in linking up with another source. There are many points in favour of this. For instance, if a bomb were dropped by an enemy on a fuel station located in an important market centre it would paralyse all business seriously: whereas damage to an electrical transmission line could be set right in a short time. Again, hydro-power service is liable to many an interruption causing inconvenience, while somewhat disastrous consequences may occur when too great a reliance is placed on fuel power service, owing to the duration of interruption being longer.

18. **Important Aspects of Hydro-Power Development.** The development of electrical transmission has greatly increased the

availability of water power. With its long transmission lines, water power will enable a large circle of consumers to be supplied without proportionately greater expenses being incurred; and, wherever feasible, a wide ramification of electric service mains should be undertaken in the countryside in order to supply power to agriculturists and for village needs. It must be remembered that the creation of greater abundance in the use of the natural energies is dependent not so much on scientific and engineering achievements as on suitably organising our affairs. Water power has a value which we cannot afford to neglect, and the combination of its interests with those of agriculture will provide the most economical method of securing the improvement of our rivers. The advantage of hydro-power increases with a well-sustained load; and, it is more economical to transmit power at a high load factor than a low one.

19. An interesting problem is the combination of water powers situated in different localities. A constant interchange is needed to conform to the load and the water conditions, and the advantage of linking up sources of power in different watersheds is great. The generating stations can then be operated to the best advantage, and the economic value is considerably increased. Regarded individually the potential power output of a station would be variable, but conjoint working produces a favourable situation. The best and most satisfactory use of water will only be secured when the flow can be regulated according to the demand; and, as large storages may not always be practicable in each of the different watersheds, the inherent disadvantege of unsteadiness in supply has to be met by linking up.

20. It has also to be noted that to obtain full advantage of the power possibilities of the rivers, the programme of their development should be carried forward over a period of years in such a way that new power units may be brought into service progressively as required, without undue increase in the investments at any one time: capital charges remaining unproductive for years should be avoided, and data of a speculative character should be excluded. The pace of the programme will be determined by the consideration that power is usually developed as a corollary of the irrigation or the navigation works; and slow progress under these might bring about a condition of stagnation.

21. The much-discussed problem of dealing with the continually increasing peak loads, in a rationally satisfactory manner, can be solved by adopting the principle of accumulating water in an elevated upper reservoir by means of pumping, and creating a power storage station. Pumped storage enables the wastage current of hydro or thermal power stations to put

water back in the reservoir, thereby converting the waste energy into valuable peak load energy for day-time consumption. The aim is to balance, as far as possible, the night power and the day power. Through this means a considerable saving in coal per generated k. w. h. is effected, and the continual uneconomic increase of the outupt of the steam power stations for peak load supply is restricted. The conversion of waste power available at night not only acts as an accumulator but also as an instantaneous stand-by in case of break-downs - a point which is of equal importance.

22. The problem is the exploitation of a rich and inexhaustible source of energy supplied by nature, which will be permanently used for general welfare, enabling the public to largely participate in the advantages offered by the long duration of life of the works and the extremely low costs of production of current. The approach to it involves the reconciliation of the clashing interests of the three principal users, viz: agriculture, navigation and industries. However much we may make a point of serving the interest of trade and industry first, the work in the field of hydro-economics will not bear fruit, if it be not successful in effecting a compromise doing justice to all the parties concerned. The chief points at issue must, therefore, be thoroughly considered, and elaborate investigations will be needed regarding the most favourable division, the most advantageous development, and the most economical size of the eventual station. Even vested interests will have to be partially subordinated for the benefit of all.

23. As a business proposition we should be in a position to realise returns on any investment commensurate with the risk involved, and the risk in the case of water power undertaking is necessarily large. It has consequently to be carefully examined whether in any particular case it is more economical to carry fuel to the market and generate calorific energy there, or to generate hydro-power where the opportunity exists and convey it to where the power is needed. This fundamental point for the financing of the water power development of the country being safe-guarded, with good market and fair treatment, hydro-power developments will be found to be very effective on account of their great convenience, the small amount of labour employed, the consequent absence of labour troubles, reduction in the consumption of fuel, smaller depreciation, and the comparatively small amount of working capital needed.

24. **Need for the Requisite Education and Training:**—It is important that the State should assume responsibility for developing the wealth-producing activities, as these alone can find employment for the people. It is necessary to stress also that a knowledge of technique is indispensable as an essential

part of the equipment needed for the utilisation of the natural resources. The effective working power of the people is very low, and the occupational structure has long been out of balance. The country is not organised for the production of wealth, and we are consequently dependent on foreign countries for many of the commodities which require technical knowledge and manual skill for their manufacture. Our young men are at present encouraged to go in for University education, regardless of how they are to utilise it afterwards.

25. Knowledge of the handling of tools and machinery is a **sine qua non** of industrial life, and the education that is being imparted in practical and mechanical subjects is wholly inadequate compared to that imparted in liberal arts and culture. It does not sufficiently prepare persons for the business of life and a radical change of policy in this respect is called for. The importance of vocational and industrial training is now being greadually realised, but much more is wanted. Instruction in mechanics and mechanical pursuits should be given in the primary and secondary schools; and, wherever possible schools should be linked with the factories so as to provide an industrial bias. The Universities should give special attention to courses in engineering and technology, higher commerce and economic sciences; and should be in the position to provide the requisite equipment and the personnel needed for industrial research. Facilities must also be provided for the deputation of students to foreign countries.

26. **Speeding up of Industrial and Other Demands:**—water power is both an industry and a producer of industries; and if power and industry can be developed along parallel lines the economic advantage is obvious. Industry forms the back-bone of a healthy natural economy and the balance-wheel of all large business. In most advanced countries it consumes more than 80% of the power made available; and the other in which hydro-projects should be taken up will depend upon the expansion of large industries and their location. By this it is not intended to imply that count should not be taken of small-scale industries. In countries like Germany and Japan, small-scale industries play an important part in the productive activities, and employ a large percent of the industrial establishments. But in the earlier stage of development, i.e., until the electric sense is brought about, the main reliance will have to be placed on large commercial undertakings.

27. Mining and electro-chemical works are usually associated with hydro-electric concerns, where financial success depends much upon a high load factor. A thorough mineral survey would make possible a great many industries to be established; and a survey of our iron deposits would seem to

be particularly justified, from the progress and improvement made in the last 15 years or so in the methods used for the production of iron ores and the manufacture of steel. Profitable operation of mineral workings is greatly facilitated by the low cost of hydro-electricity, which, if power were limited, would have no commercial value. Electro-metallurgy has also rendered it possible to have materials that were not workable by other means. It is now commercially possible to obtain many useful products, while great developments have taken place in electric smelting and refining of matallic ores. Electric smelting, though costly, has been found economically feasible on a large scale, and steel furnace operation, where exceptionally high temperatures are required, offers a profitable outlet for off-peak power even at the end of a long transmission line.

28. There is a wide scope for electro-chemical industries, for which cheap power is a primary requisite. In some cases chemical loads have been developed to convert surplus or half-peak power into a marketable commodity. The fixation of atmospheric nitrogen for the production of fertilizers demands serious consideration, in view of the diminution that is taking place in the fertility of land. The manufactures of synthetic ammonia and that of sulphuric acid are regarded as key industries. The establishment of alkali industry to provide caustic soda, bleaching powder, chlorine and hydrogen would be of great economical value. There is demand for phosphates in agriculture, and the manufacture of phosphoric acid should engage attention. Electro-chemical industries give a very high load factor: in Germany, the Caro-Frank process has enabled both the continuous output and the fluctuating portion of the water power to be utilised entirely and almost a hundred percent exploitation of the water volumes of the Alz and the Inn is being attained.

29. India is still being advised to pursue the agreeable and contemplative tenor of handicraft production. The industrial development at present is very much behind what it ought to be, and the result will be found to be amazing when a reliable supply of power is made available at economic values. The benefits are exemplified by the progress made in Mysore and by the remarkable growth of the textile industry in and around Coimbatore. The availability of cheap power helps the growth of important industries, which in turn pave the way for harnessing more water power. In addition to large industries, lighting, heating and electric steam boilers, there is demand for cement, pulp and paper mlls, artificial abrasives, workshops, shipyards, manufacture of refined oils, etc.

30. For development of the power market, railway eletrification appears to be a most attractive proposition at the out-

set: the revenue from the railway load will help to develop the power market and also to defray the railway expenses. There are definite advantages in railway electrification, viz: increased speed, increased traffic capacity of lines, increased comfort and cleanliness. In Chile there are extensive coal fields, the coal having an average value of 12,000 B.T.U. Notwithstanding this, a section of the State railways has been electrified at as high a rate as 0.64 d. a unit, and a considerable saving shown over the costs for operation by steam. What sections of the railways in India should be electrified, and the order in which they should be electrified, are questions which will require very careful consideration.The process is not likely to be rapid, but all possible effort should be made to accelerate progress in this direction. The railways are using about 7½ million tons of good coal annually, and their assistance is also needed to enable such big-scale schemes as we are contemplating to be started on business lines.

31. Industrial development requires careful planning, and a special expert organisation will need to be formed in each Province, in order to make a comprehensive survey of the industrial position and an analysis of the factors bearing thereon. The main object will be the investigation of suitable industries and the submission of schemes for the establishment of factories. Power areas should be formed and recommendations made for the gradual absorption of all sources of power where generated for public utilisation. The Report will include not only a description of the plant projected, but full details of production, cost, supply of materials, markets, and methods for the distribution and sale of the products. It will also be necessary to appoint a few qualified engineers with experience in manufacturing methods for giving effect to the proposals.

32. **Rural Electrification:-** We have given an outline of the possibilities in the direction of large industries, and indicated that it is essential to secure a sufficient number of concentrated loads, especially in the early stages. It is important to develop the wealth-producing activities of the country, so that, through a Grid System, we may be able to appropriate the profits for the extension of social benefits to the masses. The stake of the public is a cheap and reliable supply, widely distributed and available for everybody — the greatest good of the largest number and that for the longest time. The general national economic points of view must be placed in the foreground as decisive factors; and if electricity is to serve its purpose of raising the general standard of living, its main application has to be in the rural areas, where it should go to aid production and procure for the grower better value for his produce. The most important industry in the country is, and will

continue to be, agriculture. Its power development is highly essential, and this service should be stimulated. The steady development of cottage industries on a wide scale and the gradual electrification of the farm-yard must be visualised in the measures we adopt, and a part of power reserved for use by the local population, both for present requirements and prospective developments. The factory is intimately interested in what happens in the farm, and conversely, the farm cannot get along well without the factory.

33. Hydel is an important factor in rural development, its main objective being to make cheap and abundant power available over the countryside. But in order to obtain this objective, and enable a large number of people to enjoy the amenities serious efforts will have to be made to stimulate the growth of demand through the medium of cheap power; and it is naturally a matter of careful study how far it is wise to go at rates equal to or below the actual cost of production with this object in view. Excellent pioneer work will also have to be done by propaganda, education and free demonstration; and special facilities will have to be given before the advantages of electric power will come to be appreciated. It is on utilisation that the success of any power development depends, and this is particularly the case with hydro-electric power, the advantage of which increases with the load factor. Steam power works are naturally situated in the coal mining districts in order to save freight on transport and are grouped relatively close together. But if the entire country is to benefit, the giant forces dormant in river will have to be harnessed to an ever-increasing extent and utilised for the generation of electric current. The State should adopt a definite policy in regard to rural electrification by the construction of rural lines to serve entire areas, and make it possible for any person within the area of supply of electricity to demand and get it on reasonable terms.

34. At the Vienna section of the World Power Conference, it was stated that experience has shown that rural electrification is a more promising field than had at first been believed. People all over are gradually becoming "electrically minded"; hence there should be an increasing demand for electrification in the house and in industry. More than half the cost of production is for power and labour, and it is evident that the use of cheaper and more efficient power will result in great saving to agriculture. An important load, which synchronises with the periods when water is available, is the lifting of power. Irrigation pumping is very successful where there is concentration of load and large supply of water, and there are several advantages in this. One of these advantages is that water is utilised with great care and with the minimum of losses and wastage: water

is under the control of the cultivator, and the irrigation of high class crops, has proved a success. The problem of reclamation of water-logged areas, or the prevention of low-lying tracts in irrigated areas from getting water-logged, affords another opportunity for the advantageous utilisation of power for pumping. It would be advisable to depute an Executive Engineer for investigating the possibilities of load building of this class. Where concentrated pumping loads are available, it becomes practicable to connect them with high-tension net-work to furnish power to intermediate towns at rates which would facilitate the development of minor industries.

35. **Survey of Hydro-Electric Resources:**—Many years ago Mr. Meares made an attempt to obtain an idea of the hydro-power resources of India. It is felt that drastic revisions are needed in his figures. The data, however, is lacking for a reasonably reliable estimate to be formed of the potentialities of the development of hydro-power, and it has to be realised that anything like an exhaustive survey will need a very long time. There are many factors to be taken account of and properly assessed. The greater portion of the power of the rivers in their flow to the sea can never be profitably developed, as it may lie in the lower portions of the streams, or in the very small head-waters, or it may be distant from the markets. Then there is the question of storage of water in order to make it available for development of power, and it may not always be practicable from the physical and economic viewpoint to constructed reservoirs. It must also be remembered that water will be required for numerous other purposes; and detailed engineering studies will have to be undertaken to arrive at the most resourceful combination of power with the other uses of water. The importance of a planned utilisation of the water resources is however generally recognised; and the available information in regard to hydro-power possibilities will have to be collected with the view to undertake careful examinations of such of them as may be considered to be worthy of being pursued, and also to determine the order in which the various developments should be taken up.

36. In our Report on Irrigation, we stated that the volume of the surface flow of the rivers is no index to the possibilities of its utilisation for the purpose of irrigation, and the same remark applies to its energy. Water consumed is no longer available for power development, and this fact alone renders a complete estimate of the feasible power no more possible than that of irrigation. A conjecture has been made that the water power capable of development is of the order of 5.5 million kilowatts.

All we can do here is to compare this figure with the figures of certian other countries where organised efforts have been

made to collect the requisite information. From the records obtained of the National Reports made some years ago, the figures for these countries are stated to be as under:—

Country	Commercially feasible maximum turbine installation	Installed water turbine capacity
U. S. A.	53 Million Kilowatts	10.6 Million Kilowatts
Canada	31 ,, ,,	5. 3(o.2 on 1-1-40) ,,
Norway	12.1 ,, ,,	1.5 ,, ,,
Japan	10 7 ,, ,,	4 05 ,, ,,
France	7.9 ,, ,,	2.3 ,, ,,
Sweden	6.5 ,, ,,	1.5 ,, ,,
Italy	5.9 ,, ,,	4.2 ,, ,,
Germany	3.5 ,, ,,	2.0 ,, ,,
Switzerland	3.3 ,, ,,	1 9 ,, ,,
Austria	2.0 ,, ,,	0 7 ,, ,,

37. The figures quoted above are admittedly based on imperfect hydrographic and topographic data, and it is necessary to mention here that they represent the personal views of the different reporters. Nevertheless they may be taken as a guide, and we are inclined to put our estimate of the feasible power installation of India at quite double the figure of 5.5 million kilowatts. Though India is not one of the most favoured countries in respect of the volumes of the surface flow and the heads available, it has a fair share of hydro-power potentialities. It is true that the country is mainly agricultural, necessitating a correspondingly high draw-off to serve the culture of the land, and that the variations of the flow of the rivers are considerable. But there are large volumes of water which cannot be consumed; and the conditions, in most cases, are favourable for storage, as the primeval rock often crops out or can be easily laid bare. There are a few high waterfalls, and it is often possible, by damming up water, to obtain falls of 30 to 60 feet and more. The country is thickly populated and the demand for power is great.

38. The difficulties that lie in the way of making a forecast of the entire commercially feasible power, need not worry us. What is needed is to outline a programme for say the next 20 years, and to concentrate attention on seeing it carried out. This programme should be sufficiently stable and definite in the sense that no technical modification in the design stage will so affect the final results as to justify postponing a decision on the question of its adoption. Considering the great need of the country and the very inadequate progress made hitherto, it is suggested that the planning out, in this period, should be for about 4 million killowatts. It is a large undertaking and will

require a serious effort, but the labour and the cost will be amply justified. The matter is one of supreme importance to the national life of the country, and no pains should be spared to accomplishing the objective with the least possible delay.

39. It is important also that the data for further exploitation should be accumulated as rapidly as possible, in view of the essentiial condition that th esupply of the power must be in advance of the requirements of the public; and in order that the data be comparable with that of other countries it would be desirable that the basis of assessment should be an over-all efficiency of 75% and a duration of 50%. India is deficient in fuel reserves in convenient locations, and it is our duty to limit their use, transporting over long distances, when there is so much hydro-power going waste throughout the country.

40. **Forecast of Probable Expenditure in Decades:—** We must premise that all we can do at present is to give an idea of the probable cost of the comprehensive programme indicated above: we have no detailed information of any particular projects on which to base an estimate. Now, of the two main heads of expenditure, the electrical works and the hydraulic works, the latter is naturally the item of greater uncertainty. There is considerable experience to guide us with regard to the former, but the hydraulic works are of a kind which vary greatly in different localities. The initial cost of a steam system is normally Rs. 150|- to Rs. 400|- per kilowatt of capacity. That of a water-power system including the hydraulic works may vary from Rs. 300|- to Rs. 1,100|-, the average for large plants having long transmission lines probably being Rs. 675|-. For a fuel-hydro combination scheme, we propose to take an average figure for cost, of Rs. 550|- per kilowatt, and this makes the total capital needed for a capacity of 4 million kilowatts Rs. 220 crores.

41. **Moderation in Charges for Supply of Energy:—** We are definitely of the opinion that the rates for supply of energy are at present unduly high, and that progress in the utilisation of power is hampered thereby. All experience leads to the belief that if rates are made attractive, it would facilitate and speed up the electrification of the country. Electricity, as observed by Steinmetz, is expensive because it is not widely used, and it is not widely used because it is expensive. The problem to be tackled is how to obtain a cheap and abundant supply of energy, and it is in the production of hydro-electricity that the solution is to found. Here there is no material consumed, and consequently no extra payment has to be made for a fuller use. Water power becomes cheap by securing a well-sustained load, and it is necessary to offer to consumers, in the first instance, low rates. Prices must not reflect the relative scarcity at the

present moment, without taking sufficient account of the future.

42. The ultimate cost of energy is divisible into two parts viz: that depending upon capital and other fixed costs (called "demand component"), and that depending on operating cost (called "energy component"); and the most economical generating system is obtained when the total of these two parts is at a minimum. It is the item of running cost that is the crux of the problem , and this is definitely low for hydro-electric plants, when the consumption is reasonably large. The difficulty that is being experienced at present is that the average load factor in India is low; and the disadvantages in the industrial conditions are reflected in the results. Mysore, however, is said to have reached an annual load factor as high as 78%. There were certain favourable conditions which have given rise to this; and in estimating the tariff, the maximum unit charge, to allow for development, may be that corresponding to a 55% load-factor. The figure is quite conservative, and it should be possible of attainment within a few years in well-planned hydro-electric schemes, provided proper attention is given to load building. It will be worth while also to postpone allocations on account of depreciation for the first few years, until a scheme has had time to make its way, and the advantages of taking supply come to be realised. This procedure is justified in important public utility schemes; the British Grid costing some 40 million pounds not only postponed depreciation contributions during the development period, but, at the same time, was paying interest out of its capital.

43. The State has the great advantage of financial credit which enables it to raise money for rural work at low rates, and there should be no difficulty in pursuing the policy of supplying power at a reasonable charge to the public. Power given to large industrial undertakings is known to bring in a return of about 10%, and extra profits should be utilised to give facilities to the small and out-of-the-way consumers. To give promising results to the agriculturists, the average rate should not exceed 0.7 anna per unit; and railway electrifications will not be attractive unless there is sufficient traffic to enable a rate of about 0.4 anna a unit to be paid.

44. **Control and Organisation:—** In India neither planning, for unification, nor co-ordination, nor nationalisation has been attempted. There are defects in the legislative situation by which co-operation in production and distribution is impracticable, and isolated development has come to be fostered. This state of affairs must be remedied, as costs can only be reduced by large-scale production and a nation-wide unification of power through an efficient Grid System. The aim should be to lay down a cmoprehensive programme not only for power genera-

tion and distribution, but also to scrutinise the rates charged and the services rendered, and to supervise the financial policies.

45. Power resources belong to the nation and must be utilised for the welfare and prosperity of the people, and their control should therefore vest in the State: nobody would suggest, for instance, that private enterprise be given the right to construct roads or irrigation works at random. In the United States of America electrical power is correctly regarded as a public utility commodity like water-supply, gas, railway etc. Hydro-electric development is particularly monopolistic in character requiring systematic exploitation, in which it is essential not to leave any opportunity that any possible chance of utilisation be neglectd. There are spheres for useful enterprise by private interest, but they do not and cannot lie in such matters of vital concern for the whole country as hydro-electric generation. Even in the case of distribution experience shows that supply companies are reluctant to take "the skimmed milk with the cream". There must be no scramble to get at the best near-by territory and to avoid the least profitable investements. The rural area, being a thin market, cannot by itself support its service at practicable rates, and development hindered will be an injury to the people. A condition of stagnation, instead of aiding and promoting, should not be brought about.

46. We recommend that a National Power Board be appointed not only for the development of electric energy but for that of key industries and public utilities as well; the one supplements the other. The Board should be composed of eminent Engineers, business men and Industrialists, together with an appropriate number of High State Officers, and the personnel should be selected from the various Provinces and States of India. They should have powers to call for and receive the co-operation of all the local Governments and bodies throughout the country, and should be provided with appropirate financial resources for conducting their work.

47. The function of the Board should be:— first to collect and consolidate reliable up-to-date data concerning hydro-power sites available for development, hydro and thermal plants in existence, and power production and consumption in the country; secondly to coordinate, develop and integrate the supply industry; and thirdly to stimulate and guide the efforts of the manufacturing industries to be started. The Board should be empowered:—

(1) To organise technical, commercial, and statistical services under their control, and also technical education in cooperation with Indian educational centres and manufacturing firms in the country and abroad.

(2) To devise legislation for the formation of a Central Financial Trust to work in cooperation with them, and also legislation relating to such matters as general supervision, protective tariffs, standard specification, rates for energy, relations with consumers etc.

(3) To develop suitable trade relations with foreign firms with a view to starting manufacturing industry with their cooperation.

48. The organisation of such a management must necessarily eliminate as far as possible every attempt at competition within the amalgamated works. It should allow the amalgamated works to participate in equal measure, thereby ensuring that the main object shall be the most profitable exploitation of the resources. As stated already, special emphasis has to be laid on the agricultural and other interests; the primary purpose of any works for the provision of water must be to protect the country from drought, to extend the irrigated area, and to furnish supplies for navigation, for domestic, and other uses. This basic condition being fulfilled by complete collaboration with the National Water Resources Board, the exploitation of the different water and steam plants should be carried out as though all work belonged to a single owner.

49. There will be difficulties presented by the clashing interests of the different Provinces and States, who may not like servitudes created. But, if the work is to bear proper fruit in the field of hydro-economics, every endeavour must be made to reconcile the interests of the principal power developers and users, just as it will be necessary to negotiate with agricultural interests. The Provinces and States may supply the current generated to electricity concerns in whose jurisdiction the current is produced. There must, however, be adjustment on the main points at issue, and it will be necessary to export the extra current which cannot be utilised to the large-scale enterprise which is working with high tension. To attain a rational utilisation, it is essential for technical and economic reasons that efficient coordination within the major generating and transmission systems be established: planning of a unit is not of much use unless the whole is coordinated.

50. Supply of power to densely populated areas and concentrated loads should be organised as a commercial undertaking; and special committees will need to be appointed to make surveys of the probable power demand, the transportation and marketing facilities, and to give information on the installed horse power. They will analyse imports and exports in order to show the needs of the home markets (imports) and determine what materials, fit for providing occupations to indigenous

labour, are being sent out of the country in a raw or semi-finished state. Their functions will also be to draw up schemes for cottage industries, as is being done in parts of France and Italy, and to put forward proposals for the change over from steam and oil driven machinery to electric drive.

51. An advisory office should be inaugurated, in addition to drawing attention to the non-utilised vast sources of water power, with the view to inform the public of the outstanding importance of utilising water power. It is an important consideration to be taken account of, that whereas the price of fuel will be continually rising, the cost of power from water is likely to fall in course of time.

52. The promotion of the material interests of a country depends to a great extent upon the furtherance of scientific and technical research; and there is great need for the establishment of a Power Research Institute. Techinical research, on which industry has to depend for its economic existence in the international field, forms one of the main considerations today, and crores of rupees are being spent on it. The importance of bringing about developments by the translation of thought into practical achievements is so great that many large concerns maintain laboratories for this purpose. In one Research Laboratory in Germany (Siemens) the total annual expenses are said to exceed the amount of the devidends distributed.

53. **Conclusion:-** Bearing in mind the fact that India offers greater possibilities for reasonable industrial development than most countries today, there can be no doubt that every effort should be made to utilise the water power which is running to waste. There exists hardly a branch of industry where water power cannot be employed. In advanced countries, even small and insignificant water powers are exploited to the utmost extent for indusrial and trade purposes. Of the total output of electric energy in Bavaria, the share of the water power, as far back as 1928, was 75.4%; and the water power exploited or in course of development, represented about 30% of the total water power resources worthy of development. Sweden and Italy have made themselves practically independent of outside coal. The total potential hydro-electric power of Japan is said to be 10.7 million k.w. (normal flow) of which about 4.05 million have already been harnessed. Hydro-electric development is a sound commercial enterprise, provided it is efficiently managed and an effort is made throughout to avoid, as far as possible, the construction of works which may tend to lie idle for any length of time, and thereby involve the payment of interest on unproductive work.

54. At present there is a vicious circle of industries that require power, and of power looking for an assured outlet; and

neither side is inclined to move unless certain of the co-operation of the other. It is here that the particular advantage of water power comes in, by invariably proving cheaper on a fuller use being made. Water power, with its long transmission lines, also enables a large circle of consumers to be supplied, and even its discontinuous power available for 6 to 8 months is of value for utilising in rural industries. These considerations may not be worth much in money values, but they give returns in ways which make for a higher civilisation, by the extension of social benefits to the masses. It is our duty to take advantage of them and to widen the tributary areas to the utmost extent so that the large revenues from the profitable undertakings can bear the burden. This policy should be followed, and electricity should be developed, transmitted and sold without profit or loss, the State being satisfied with a low over-all return, sufficient to meet the interest for the loan it raises to carry out the undertaking. If the economic advantages are fully appreciated, the policy of adhering to the development of hydro-power, even in times when difficulties assail enterprises, will be found to prove correct.

NOTE ON THE FUNCTIONS OF THE IRRIGATION BRANCH, PUBLIC WORKS DEPARTMENT, UNITED PROVINCES, AND ITS POTENTIAL CONTRIBUTION TO NATIONAL ECONOMIC PLANNING.

Under present conditions agriculture plays a predominating part in the economic life of the United Provinces, and the Irrigation Branch, Public Works Department, or, as it will be termed hereafter, the Canal Department, performs the valuable function of supplying the first essential raw material of agriculture as an economic activity, or industry, water. In no country has irrigation attained the degree of development that it has deservedly achieved in India. The canals are responsible not merely for the prosperity of innumerable cultivators but also for a great part of the provincial revenues that make development in other fields possible.

2. The canal department in the United Provinces is somewhat unique in the part that it plays in the dual development of agriculture and industry. On the Upper Ganges Canal use has been made of the power available at canal falls to generate electrical power at a number of power stations and thus to energize a very extensive grid. The power thus generated is applied to pumping water from tube wells in areas uncommanded by existing canals, and thus developing agriculture. This load may be regarded as a basic load : in addition power is supplied for domestic purposes to a great number of small towns which would otherwise be denied this amenity, and a number of industries throughout the grid system are supplied with "cheap power", that is "cheap" in the sense that it is supplied at a cost that protects Government from loss and permits of the earning of a reasonable profit by industrialists. The power is supplemented by a highly efficient modern steam coal station at Chandausi. Another thermal station at Muradnagar has been sanctioned. The Grid is fully loaded up and immediate extension is necessary. Scope exists for generating another 4,000 K.W. on the Ganges Canal and about 50,000 K.W., as at present known, on the Jumna river between Dehra Dun and Chakrata. In Fyzabad, where there is a large area of cultivated land which requires protection, an independent steam coal station has recently been constructed. The basic load is the pumping load from the Gogra River which supplies the Fyzabad canals. In addition, power is utilized for domestic purposes in Fyzabad and for small industries. There is thus in the west a wide-spread grid already in operation and in the east a nucleus at Fyzabad. The eventual extension of such a grid to the entire Province must depend on the power resources available and the extent to which the existing scattered load can be enhanced in order that a grid extension might be justified. In

Appendix A are tabulated the areas commanded, areas irrigated and other statistics bearing on the agricultural development associated with the Canal Department. The existing and potential power resources of the Canal Department are also given and the present consumption under industrial, domestic and agricultural heads.

3. The question now arises how the standard of living can be enhanced by the development of the existing agricultural and industrial resources, and the improvement of agricultural production.

In respect of agriculture the Agricultural Department is clearly primarily concerned. The Canal Department is endeavouring to increase agricultural development by the extension of existing canal systems wherever increased economy in the use of existing supplies and the more scientific distribution of water makes such a course possible. Such a project is now being prepared for the Sarda Canal, which will now irrigate the country on the left bank of the Ganges up to Soraon, near Allahabad. On canals where the existing supplies do not justify an extension of the system, internal development is sought by the introduction of modern methods of design and distribution and the reduction of channel losses and wastage to a minimum. A recent example of such internal development is the remodelling and extension of the Mat Branch system which has brought the benefits of irrigation to a large additional area, raising the canal irrigated area from 1¼ lakh acres to 2¼ lakhs.

4. The extension of canals to any new area automatically improves agricultural production. This however is merely a by-product of canals. The task of improving production devolves on the Agricultural Department, but a most important problem is the development of types of crop which are most profitable when irrigated under normal canal conditions. This involves the closest association and liaison between the Agricultural and Canal Departments. The first requirement in respect of agricultural development on canals is, therefore, increased co-ordination of the activities of the Canal and Agricultural Departments and yet closer association. The canal grid has great potentialities as a nucleus for an eventual comprehensive grid for the distribution of cheap power. At present the volume of Provincial industrial consumption met by the grid is small and it is evident if the goal is to be the eventual unification of all sources of power supply the task must be entrusted to an Electricity Board.

5. In respect of the time limit to be set for a given degree of development and the element of elasticity to be provided in any plan, the Canal Department, regarding its irrigation activities, is fortunately situated. As to the power made

available for industry in a given time the pace to be set must clearly be governed by the simultaneous creation of a demand and the development of existing loads. On canals all additional supplies made available are immediately absorbed by cultivators previously denied irrigation. Where facilities already exist increased supplies lead to an increase in the irrigation intensity and to an immediate increase in material prosperity. In the Irrigation branch, therefore, progress and development are continuous, and the results to be achieved in any quinquennium or other arbitrarily assigned period will depend very largely on the funds made available for extensions and the skill with which the internal departmental programme is framed.

6. The greatest bar to progress in development in State institutions is the absorption of the staff in matters of routine. Economy, in the proper sense of the word, the "frugal and judicious expenditure of money", is essential.

There can be no planned development in the Canal Department without the frugal and judicious expenditure of **additional funds.**

7. This Department is not immediately concerned with any census of production. In respect of agriculture the Canal Department is a source of production inasmuch as certain types of crop, of a profitable kind, such as cotton, high grade rice and sugarcane can hardly be grown without canal irrigation. Subsidiary or small scale cottage industries of the kind highly developed in Japan are admirably suited to a wide spread grid of the type recently constructed. With large scale power-driven industries the Canal Department has not up till now been concerned but demand for supply of power to medium size industries is now rising and negotiations have recently been in progress for supply of power for the following factories:

(1) Caustic Soda factory at Saharanpur consuming 1,200 K. Ws.

(2) A Ghee factory consuming 400 K. Ws.

(3) A Spinning factory consuming 200 K. Ws. and

(4) A Cardboard factory consuming 230 K.Ws.

Enquiries are also being made by industrialists for the supply of more power and this will all necessitate extension of our power houses in the immediate future.

8. The canal department is largely responsible for training its own staff in technical matters and recruits its officers and subordinates from the Thomason Civil Engineering College, Roorkee. There are no difficulties in respect of the staff entrusted with the civil engineering side of the department. The

method of recruitment of staff for the hydro-electric grid, and the means of securing practical training for such engineers is dealt with exhaustively in the Report on the Practical Training of Engineers which is under consideration.

9. The chief handicap of the agriculturalist*, lack of water, is met by the Canal Department within its sphere of operation. The excessive fragmentation of agricultural land is an undeniable handicap in the distribution of water and consolidation would lead to increased economy and further development. Improved communications by means of roads, metalled and unmetalled, are essential if the cultivator is to derive increased prosperity from its money crops.

10. The existence of a canal system insures a great measure of agricultural insurance † of a valuable indirect kind. It is not sufficiently known that prior to the construction of the Upper Ganges Canal, which now covers the most prosperous districts in the Province, the districts now served were visited by one or more disastrous famines. Insurance as afforded by canals takes the form of increased material wealth and increased powers of resistance. The protective canals constructed in Bundelkhand and Mirzapur were introduced solely with a view to averting famine. Insurance in its basic form already exists. The land being State owned the failure of crops due to disasters such as flood, hail, etc. is mitigated to some extent by rent and revenue remissions, and also, when the loss is severe, by the entire remission of the water rates.

11. With the single exception of the Gogra River and the Ganges below Allahabad, the rivers of the Province do not lend themselves to water transport.** The Upper Ganges Canal, the Lower Ganges Canal and the Agra Canal were all originally designed to serve the dual purpose of irrigation and navigation canals. With the increase of railway communications, inland water transport, despite the very low rates charged, languished, and with the increase in motor transport inland navigation is moribund. The intense internal development which has now taken place in canals, and the over-riding requirements of the cultivators, make any resuscitation of canals as waterways impossible. Such a project would in any case be impracticable, and uneconomic.

12. The rivers of the United Provinces, particularly in the eastern sub-montane area, give rise to all the problems of floods, erosion of banks, and shifting of the river bed, inseparable from all rivers flowing in, and transporting alluvial material.‡ In the past it has been recognised that changes of

* Question 44.

** Questions 96, 97.

† Questions 49, 50.

‡ Question 112.

this character are inevitable and that protection must be given where the floods spell disaster in areas which from their 'location' should ordinarily be immune from damage, and that riverain towns, however faulty their location, must be protected. There are numerous bunds of ancient date privately constructed for the protection of local interests which serve as a local protection but by reducing the natural waterway raise the flood plane elsewhere. It is recognised that if floods are denied a means of abating their intensity, by flooding in low lying areas (in which the precarious nature of the cultivation must be recognised), the result can only be the intensification of damage elsewhere. The problem requires a broad outlook and a judicious policy which makes some attempt at balancing local interests and general welfare. The appointment of a technical board to advise Government is under consideration. For river training, in the sphere of their own operations, the Canal Department, the Railway Administration, and the Buildings and Roads Department are severally responsible. The Canal Department is responsible for the maintenance of river training works in connection with their head works, and either separately, or associated with the Railway administration and the Buildings and Roads branch have advised Government on such problems in the past.

13. It has not been possible in this brief note to do more than sketch the activities of the Department and to employ the qustionnarire as a system of annotation. This possibly may lead to a correct perspective. A categorical reply to the questionaire would serve a very limited purpose and it is hoped that this note may prove useful in assessing and appreciating the functions of the Canal Department and its potentialities in national planning.

APPENDIX A.

Statement No. 1.

Statement showing culturable area commanded by each major Canal system in the United Provinces.

Canal System.		Area in acres.
Upper Ganges Canal	..	4,609,000
Lower " "	..	5,027,000
Eastern Jumna Canal	..	1,191,500
Agra Canal	..	1,241,400
Sarda Canal	..	6,997,391
State Tube-wells	..	1,462,000
Miscellaneous	..	2,838,209
Grand Total	..	23,366,500

APPENDIX A.

Statement No. 2.

Statement showing area irrigated for main crops, by each major Canal and Tubewell systems in the United Provinces during the year ending March 31, 1938.

Serial No	Name of Crop	Area irrigated by							Total Area Irrigated	Remarks
		Upper Ganges Canal	Lower Ganges Canal	Eastern Jumna Canal	Agra Canal	Sarda Canal	State Tubewells	Miscellaneous (Minor Systems)		
		Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	
1.	Sugar Cane ...	2,50,755	59,920	84,545	34,492	1,56,707	79,210	30,749	6,96,378	
2.	Wheat ...	3,44,611	2,85,456	97,758	99,973	4,45,555	2,38,474	35,434	15,47,261	
3.	„ mixed with Barley and Gram ...	67,768	1,14,000	10,750	17,426	50,796	4,167	2,16,305	4,81,812	
4.	Barley ...	40,525	51,175	875	35,277	25,074	3,376	2,271	1,58,573	
5.	„ mixed with Gram and Peas ...	1,05,380	1,26,417	664	12,232	41,046	7,476	5,049	2,98,264	
6.	Rice ...	35,663	81,933	57,691	4	1,23,678	2,584	1,01,915	4,03,468	
7.	Gram ...	67,068	43,945	3,918	58,729	44,415	3,749	24,757	2,46,561	
8.	Peas ...	91,490	80,871	6,991	8,937	44,502	8,498	3,611	2,44,900	
9.	Other Crops ...	4,17,366	2,61,444	95,350	1,26,687	81,352	71,049	55,780	11,11,028	
	Grand Total...	14,20,626	11,05,761	3,58,542	3,95,757	10,13,125	4,18,583	4,75,871	51,88,265	

APPENDIX A.

Statement No. 3.

Statement showing area irrigated during Kharif 1938 and Rabi 1938-39, by Canals and Tubewells in the United Provinces.

Fasl.		**Area irrigated in acres.**
Kharif 1938 (actuals)	..	1,886,647
Rabi 1938-39 (approximate)	..	3,387,000
Total	..	5,273,647
Say	..	5,274,000.

APPENDIX A.

Statement No. 4.

Statement showing consumption of electric power during 1937-38, on the Ganges Canal Hydro-electric Grid.

	Domestic	Industrial including losses	Agricultural	Miscellaneous	Total
	Units	Units	Units	Units	Units
1. Distributing Companies ...	17,15,817	94,55,480	3,21,499	1,59,456	1,16,52,252
2. Municipal Board ...	10,38,393	16,35,361	26,524	...	27,00,278
3. State Railways ...	2,53,525	1,69,915	...	23,01,569	27,25,009
4. Cantonments ...	3,79,195	1,85,992	...	7,02,236	12,67,423
5. Other Government Departments ..	37,951	1,06 182	...	486	1,44,619
6. Private Consumers ...	1,72,584	4,01,933	57,701	1,48,446	7,80,664
7. State Irrigation Pumping ...	—	—	...	34,93,312	34,93,312
8. State Tube-wells ...	—	—	...	237,35,434	237,35,434
9. Departmental Consumers ...	27,680	18,032	...	...	45,712
10. Rural Consumers ...	67,162	8,35 632	18,98,738	...	28,01,532
11. Miscellaneous ...	17,215	—	...	...	17,215
Total ...	37,09,522	1,28,08,527	23,04,462	305,40,939	493,63,450
Approx. for 1938-39	38,00,000	2,02.16,769	51,63.000	434,21,675	726,01,444

APPENDIX A.

Statement No. 5.

Statement of Miscellaneous Statistics to the end of 1938.

1. Number of towns served by the Ganges Canal Grid 73

2. Mileage of transmission lines on the Ganges Canal Grid 4,351

3. Capacity of existing power stations on the Ganges Canal Grid .. .. 29,700 K.W.

		K.W.	
Bahadurbad	..	4,400	
Nirgajni	..	4,000	
Chitaura	..	3,000	
Salawa	..	3,000	
Bhola	..	2,700	
Sumera	..	1,200	
Palra	..	600	
Chandausi	..	9,000	(Steam)
Oil standby	..	1,800	
		29,700	

4. Capacity of steam station at Fyzabad (Fyzabad Electricity and Gogra Supply Scheme) .. .. .. 2500 K.W.

5. Area irrigated by Gogra Canal in Rabi 1938-39. 9900 acres

6. Area irrigated by State tubewells in 1938-39 5,35,000 acres

7. Capacity of the proposed steam station at Muradnagar recently sanctioned .. 9,000 K.W.

8. Capacity of the proposed Hydro-electric station at Mohammadpur .. .. 4,000 K.W.

PART IV

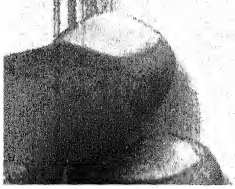
Report

on

FUTURE OF WATERWAYS

by

G. L. MEHTA



FUTURE OF WATERWAYS

by

G. L. MEHTA

Waterways have played an important part in the economic, social and cultural development of India. The Indo-Gangetic plain has been the home of "Aryavarta" and some of the most sacred cities as well as prosperous towns of antiquity have been situated on the banks of rivers. These waterways, natural and artificial, have functioned in a variety of ways—they not only supply water and irrigate the land through which they flow but also provide the means of communication for the carriage of men and materials which, despite the passage of time and the development of other and quicker forms of transport, has still not lost its importance. These rivers and canals should be looked upon along with land, minerals and forests, as one asset of the many which are interwoven with the life of the people. Waterways in our country did, indeed, play such a vital part that the respect paid to "Mother Ganges" or the "Sacred Krishna" was no mere accident. They have been the source of life and movement of the community.

During the last century, however, waterways gradually fell into neglect. They have not been developed and have indeed been allowed to deteriorate mainly owing to a bias for railways in transport policy. The results are writ large in the economy of the country. We are faced with serious problems of soil erosion while devastating and recurring floods are a perennial menace. Inland navigation as an alternative mode of transportation has not been developed and our sources of power supply have remained unexploited. It is a matter of history how the railways have hampered the development of inland water transport and even coastal shipping in our country. In the Report of the India Railway Committee (1920-21), whose recommendations led to the nationalisation of Indian Railways, it has been mentioned how the railways had at times carried on unfair competition with water transport. Specific examples have been quoted of manipulation of railway rates in order to defeat water competition which led, for example, to the extinction of the Broach Port and the virtual closing down of the Buckingham Canal in Madras. While less than a hundred years ago, Calcutta was connected with Benares and even Agra through the river route, many of these waterways were allowed to silt and decay and die away. No adequate steps were taken for controlling the course of rivers, or for establishing training works or embankments or dams. Experts and Committees recommended measures for the improvement and better utilisation of water resources. But as is common in our country, these recommendations have large-

ly continued to decorate the archives of the Secretariats. Only during the recent war, it was realised how the neglect of waterways in the past has been detrimental to the economic interests of the country. The pressure of military and high priority traffic on the railways combined with the depletion in the rolling stock led to unprecedented congestion which would not be offset by an alternative form of transport. Nor was that all. The removal and destruction of boats in pursuance of the policy of denial seriously interfered with the movement of rice in a predominantly riparian Province like Bengal in the year 1942-43. Undoubtedly, this was one of the principal causes of the famine which overtook Bengal.

There is, therefore, now an increasing realisation of the value of waterways and a revival of various forms of water transport in the country. Several Provinces in India are peculiarly suited for the development of these waterways and their maintenance is as important to their economic well-being and progress as the construction of roads and railways. Navigable rivers are, for instance, mostly spread through East Bengal and Assam. East Bengal is the main centre of jute ; Assam supplies the world market with tea. Considerable quantities of these commodities are brought by inland vessels and shipped directly into ocean-going steamers for carriage to coastal and foreign ports. There are further possibilities of developing river transport in Bengal. Similarly, the Buckingham Canal and the Krishna Canal in Madras are being increasingly used for inland transport and are capable of still greater utilisation. In the industrialised countries of the West, waterways are being systematically developed and encouraged on the basis of a multipurpose programme. In Germany before the War, and in Soviet Russia, rivers have been regarded as great sources of potential wealth and strength; and plans have been evolved for getting the most out of them. But the Tennessee Valley Authority in the United States, described as "TVA"—with the Americans' well-known fondness for alphabetical letters—is the classic example of a comprehensive scheme of river development. The TVA has harnessed greater water power for constructive purposes such as restoration of fertility to soil, provision of facilities for navigation and opening up of new sources of electric power. The total investment of 700 million dollars in river development provides not only power but also the benefits of navigation and flood control. America's inland waterways have hitherto been used extensively for carriage of such commodities as coal, oil, sand and gravel and wheat. The TVA created a separate organisation called the "Tennessee Valley Waterway Conference" for promoting the use of the river for navigational purposes. The benefits of, a 650 mile navigable channel go to several industries using it as well as to shippers and consumers of grain, oil and

other commodities. Special locks have been designed which raise the barges from the level of one lake to another. Today huge modern tow-boats powered by diesel oil engines move up and down the channel pushing double columns of barges and the cargo is no longer limited to raw materials. Billets of steel, cotton goods, grain, millions of gallons of petrol and oil as well as machinery, merchandise and even automobiles, military ambulances and jeeps are carried on these channels. It has been clear that what is involved in the use of the river is far more than transportation rates and savings. What has always been true of water transportation has been proved here also, namely, that new industries are rising along its course. The TVA is a great example and an inspiration for those who desire to harness natural resources for public benefit on a democratic basis.

In our country, too, waterways offer immense possibilities for navigation and the use of water resources for irrigation and hydro-electric power will tend to solve problems of food-supply and help in decentralising and developing industries. Water transport, it is well-known, is economical especially for the carriage of articles in bulk and it is essential to improve and extend waterways so as to enable merchants, producers and manufacturers to utilise them to a larger extent in the years to come than they have been able to do hitherto. In the industrialised countries of the West, waterways are looked upon as supplementing railway transport not only as feeders but as an alternative form of communications without which the development of a country's transport system is not complete. The benefits of cheap water-carriage over long distances have been realised at an early stage in such countries and an efficient system of inland waterways has been built up. In U. S. A., for example, raw materials are carried to steel plants from one thousand miles over the inland rivers and canals which have been specially developed and adapted for the purpose. We have in our country such schemes as the Damodar Valley and the Teesta Valley Projects as well as the Kosi Dam Project in the north and the Tungabhadra, Cauvery and Godavari Projects in the south. What is wanted is to improve the condition of these waterways so as to make the rivers, canals and other systems navigable, as well as to adapt the irrigation canals for inland traffic and construct new artificial waterways wherever possible. A beginning has been made by the establishment of a Central Waterways Irrigation and Navigation Commission under the Chairmanship of an experienced Indian Engineer. The creation of River Research Institutes is also a step in the right direction. Although legislation in respect of control and regulation of waterways in Bengal has been passed, necessary machinery has not yet been set up and brought into operation.

Inland waterways are a Provincial subject, but since navigation concerns other forms of transport and since rivers pass through more than one Province or State, the question of co-ordination as between railways and waterways as well as between the various Provinces and the States and the Provinces and the Centre is pre-eminently a subject which should fall within the sphere of the Central Government. It is necessary to integrate the various problems involved into a unified whole. Natural resources cannot be divided and classified in order to conform always to the artificial organisation of governmental structure. What nature has made as one, man has to develop as one. Well has it been said by David E. Lilienthal, author of the interesting Penguin Book on TVA, **Democracy On The March**, that

> "the river has become a kind of school room, like the demonstration farm, in the unity of resource development. Minerals and forests and the products of the farm were seen in specific cases to be inter-related closely with industry and transportation. The river like phosphate and power, became a stimulus to a new kind of thinking and that thinking bred new factories, new industrial ideas and the further release of creative human energy".

We have before us issues no less vital and no less urgent in respect of development of our waterways and water resources. If we can develop national initiative and feel a sense of urgency, we can grapple with these important tasks and harness these rivers, canals, khals and various waterways for creative and beneficial purposes.

RESOLUTIONS PASSED BY THE NATIONAL PLANNING COMMITTEE ON THE REPORT OF THE SUB-COMMITTEE ON RIVER-TRAINING AND IRRIGATION

Part I of the Report of the Sub-Committee, dealing with Irrigation, was presented by Nawab Ali Nawaz Jung, the Chairman of the Sub-Committee, on the 3rd May 1940. Mr. U. N. Mahida, Secretary, was also present. Discussion continued on the 4th May, and the following resolutions were passed.

1. With a view to obtain a high degree of coordination and correlation of effort, the establishment of a National Water Resources Board, for the conservation and utilisation of water resources in the country, is recommended.

This Board will deal with irrigation, navigation, flood-control, river management, hydro-electric power and use of water for dietetic purposes.

The functions and duties of the Board will be to advise and assist the Administration through:

(a) the preparation, development, and maintenance of comprehensive plants;

(b) surveys and research; and

(c) the analysis of project for coordination and sequence.

2. Progress at present is greatly hampered owing to uncertainty of water titles, and we recommend that Inter-Provincial-State Commissions be arranged for reconciling the various interests and conflicting water rights.

These Commissions will consist of one representative each from the Provinces and major States interested in the waters, and two independent members from the Water Resources Board.

3. There is great need of extending the system of permanent gauging stations on all rivers concerning which records of flow are important for planning water resources.

4. We also suggest the systematic undertaking of research and investigation to determine extent and availability of the ground-water supplies, and the relation between their use and depletion.

5. It is important that our rivers should be developed to the greatest possible extent and effectively utilised at the earliest practicable date. For this purpose conservation of water by storage has become a matter vital to the future growth and the development of the country, and we recommend the

initiation of extensive Reservoir Systems commensurate with the needs of the country.

6. We recommend that no time be lost in drawing up and carrying out a construction programme for an addition of about 12 million acres under "Government Canals and Reservoirs" in the ensuing two decades.

7. We recommend that a detailed land classification be undertaken to determine whether the land is worth the water that is to be applied to it.

8. We recommend that steps be taken for agricultural planning to be tied in closely with the water control programme. Where perennial irrigation is to be practised, a suitable system of agriculture should be developed beforehand.

9. Where the irrigational interests are large, we recommend that Cooperative Organisations should be established for:

(a) the careful preparation of land for irrigation;

(b) the distribution of water under fixed rules and discipline.

(c) the carrying out of the minor drainage operations, and

(d) taking steps for the prevention of swamps, stagnant pools, the spread of malaria, etc.

10. We recommend that suitable laws should be enacted to entrust the upkeep of the numerous minor tanks to the village communities concerned.

11. We consider that irrigation management should be recognised as a distinct profession and recommend that steps be taken for providing the requisite training.

* * *

The Final Report, Part II, of the River Training & Irrigation Sub-Committee, was presented on the 21st June by Nawab Ali Nawaz Jung Bahadur, Chairman of the Sub-committee. Mr. U. N. Mahida, Secretary of the Sub-Committee, was also present. Discussion continued on the 22nd June, and the following Resolutions were adopted :—

1. Considering the ever-present danger to the social security or life of the people, we feel that flood abatement and protection measures should receive the closest attention. Temporary expedients so far have proved to be of little avail. A very comprehensive policy is called for, and every possible method of the solution of the problem will have to be analysed, as regards its advantages and disadvantages, and examined in respect to its feasibility, its dangers, and its cost.

2. The conclusion we have reached is that flood and famine are two aspects of one and the same problem, viz: the full economic development of the water resources of the country for the service of man. The development of flood-protection policy should, therefore, not be separated from that of the national policy governing water resources in general. We are confident that to harness the resources, so as to secure the greatest public benefits for all purposes to which water can be put, will be not only wise statesmanship but good economics.

3. We find that the policy of haphazard raising of flood banks in defiance of the rights of rivers to have sufficient space for their accommodation has failed to accomplish its design, and experience has shown that this policy has led to disastrous results. We recommend that requisite control be exercised over such harmful constructions, in which due attention has not been paid to the laws of flow.

4. We suggest that there should be a proper planning of settlements, and that the utmost care be exercised in future to prevent commercial developments on land which is not fitted for human occupation.

5. We wish to draw attention to the prime importance of maintaining river systems in efficient working order, - a phase of the problem in which united action on the part of the people and of the State is indispensable. If rivers are to remain efficient flood carriers, such harmful acts as indiscriminate stripping of forests, unnecessary removal of vegetation, improper tilling, extensive grazing, unsuitable drainage, and unduly great abstractions of the low flows of rivers in their upper reaches, should be avoided. It should be realised that the consequences involved by such acts are vast. They lead to flood impetuosity on the one side, and on the other side, to deterioration and decay of rivers, by lowering of the water-table and by flood-plain deposits growing coarser. It is necessary to restore woodlands, to afforest watershed areas, to adopt every other practicable means of detaining water and retarding flow, and to improve the drainage.

6. A matter that needs early attention is the excessive grazing by an animal population out of proportion to what the country can bear without deterioration; and in this connection we suggest that means be devised for reducing their number by having a more limited and better stock.

Note: A further recommendation of this Sub-Committee to the effect that "feeding grounds must also be restricted, and the growth of fodder crops and the practice of stall feeding encouraged", should be considered along wth the Reports of the Animal Husbandry and Soil Conservation Sub-Committees.

7. With the increase in the human and the animal populations, another problem, viz: that of soil erosion, has assumed enormous proportions, and we suggest the provision of windbrakes, construction of field embankments, and contour trenching as protection against onslaughts from erosion. The appalling waste of valuable top-soil is one of the biggest problems confronting the country.

Note: This subject must be further considered with the Report of the Soil Conservation Sub-Committee.

8. We have already suggested "the systematic undertaking of research and investigation to determine the extent and availability of the ground-water supplies, and the relation between their use and depletion". We desire to lay emphasis on this, as the lowering of the water-table in certain areas is leading to a gradual increase in the dryness of the ground.

9. To concentrate on flood problems, we consider that a Flood Branch be attached to the Irrigation Department and a Soil Conservation Service be started in the Deparment of Agriculture.

Note:- Their administrative arrangements will, however, have to be coordinated with those recommended by the Soil Conservation Sub-Committee.

10. We regard storage of waters, on an extensive scale, as the backbone of successful flood operations, and we are confident that this will be found to be generally practicable, and that on many rivers it can be achieved at a reasonable cost.

11. To enable River Training Works to be carried out effectively we suggest:—

(a) that accurate contour surveys be made of the areas liable to floods;

(b) that hydrological data be amplified and kept up-to-date;

(c) that flood recorders be installed at key points whereby the variation of the surface slope could be recorded automatically;

(d) that an intensive study be made of each basin and each problem in that basin;

(e) that a record be maintained of the improvement or the deterioration of the rivers and their branches;

(f) that early steps be taken towards the clearing up of the water rights between the States interested.

12. We recommend that:—

(a) a Department of Hydrographic Survey be established;

(b) the Meteorological Department should have a section on Hydrology attached to it, and the service of flood forecasting and warning should be taken up as a matter of paramount importance.

13. The problem of River Training involves many highly complex engineering questions, and, in many phases of it, advance will best be made by research. We therefore recommend the establishment of one or two fully equipped Hydro-Technic Research Institutes, as well as a number of local laboratories dealing with local problems.

14. In the undertaking of river training works, harmonious action between those interested in the waters is essential, so that there may be no misdirection or dissipation of effort. As problems of Governmental relations arise in negotiating agreements for the execution of the works, in apportioning costs etc., river training must be regarded as a federal subject and not left to individual states. The Federal Government should also participate in the appropriations needed for flood protection. These are as essential to the general welfare as appropriations for famine relief, and they are, therefore, just as necessary for the State to undertake.

15. To deal with the problems in each major river basin, more especially those subject to frequent floods, we consider it necssary to have a Statutory Authority on the lines of the Tennessee Valley Authority in the U. S. A.,

Note:—This would especially apply to the Ganges and the Indus, and possibly to the Mahanadi rivers.

QUESTIONNAIRE ON RIVER TRAINING AND IRRIGATION, ISSUED BY THE NATIONAL PLANNING COMMITTEE, AS GIVEN IN RED BOOK I.

44. What are the handicaps which affect the maximum utilisation of the available agricultural wealth and resources of your Province in regard to water-supply?

49. What are the principal risks to which agricultural production in your province is exposed, e.g. from the shortage of rains or inadequate water-supply? What measures have been adopted in the Province for insuring against such risks ?

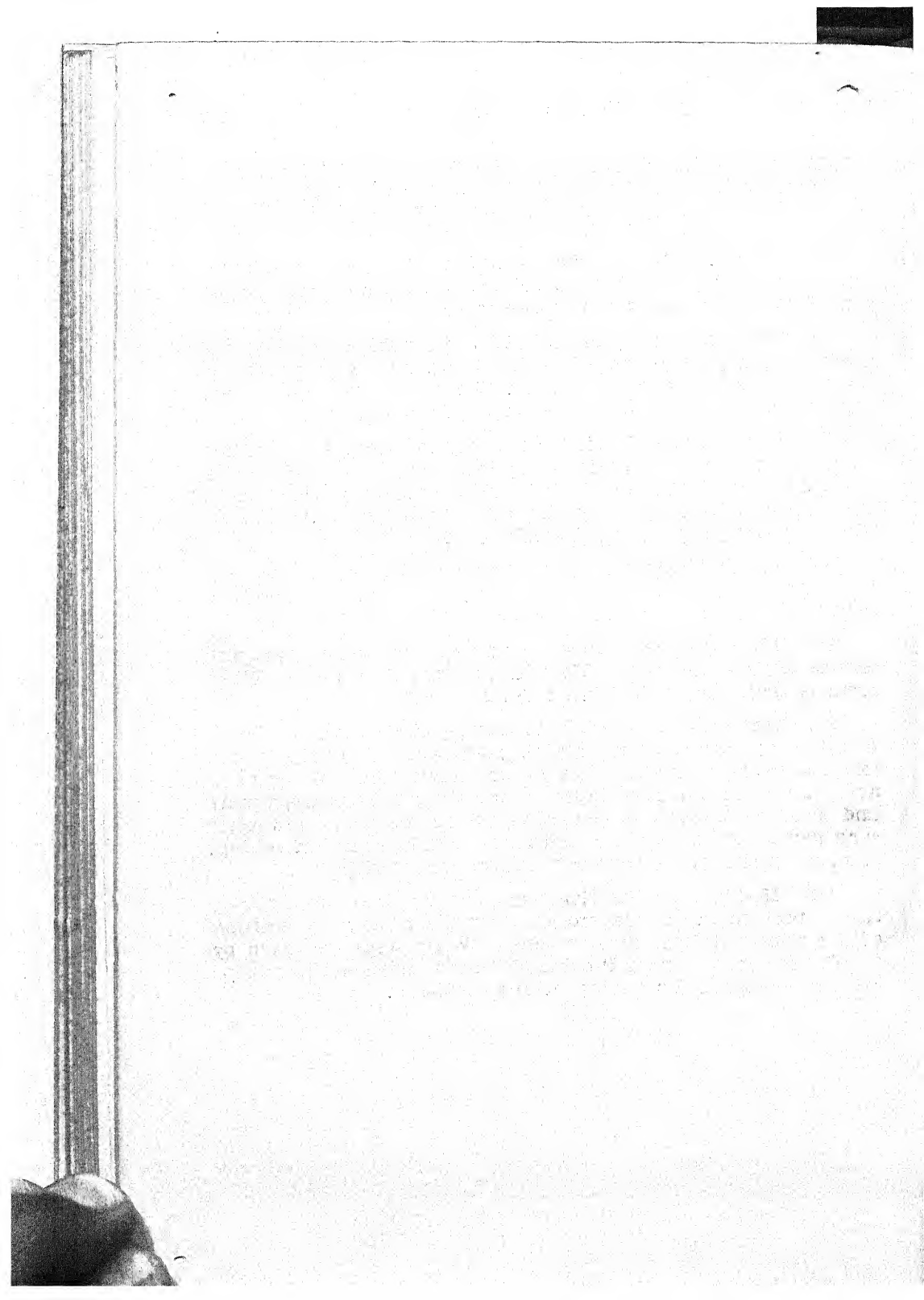
50. In what direction is it necessary to extend in your Province the principle of agricultural insurance to guarantee the agriculturist against the main risks of his occupation, e.g., shortage of rains, failure of crops, fodder, pests, weeds and floods, diseases amongst plants and cattle, etc ?

95. To what extent is your Province interested in regard to water transport by river, coastwise, or overseas shipping, including building as well as operating ships ?

96. What are the facilities for an efficient water transport service in your province ? How far are they developed ? What room is there for their further development ?

97. How far is it possible to develop and increase these facilities by means of maintaining adequate channels, in the existing rivers, or making navigation canals from the rivers so as to interlink the river system; providing the necessary port and terminal facilities at central points on the rivers, and other such devices suited for the adequate development of cheap, efficient inland water transport within the Province ?

112. How far do the rivers in your Province, if any, give rise to problems of floods, erosion of banks, silting and shifting of the river-bed from time to time ? What steps are taken by the Government of your Province hitherto, and what new steps are contemplated for solving of any of these ?



SUMMARY OF DEVELOPMENTS

The principal developments since the National Planning Committee began its work in 1939 are :

The Emerson Barrage in the Punjab, and the Ganges Tubewell Scheme in the United Provinces. (Most of these details are taken from the Indian Year Book 1947).

Emerson Barrage and Haveli Canals. This Project, completed in September 1939, consists of a barrage below the junction of the Chenab and the Jhelum. It is meant to utilise the winter infiltration and summer waters of the combined rivers, to give controlled and better perennial irrigation of the Sidhnai canals off-taking from the Ravi, and non-perennial controlled irrigation to the inundation canals taking out of the Chenab, and also to irrigate some new areas. The canals are designed to provide a probable perennial irrigation of 513,344 acres in a gross area of 694,278 acres; and a probable non-perennial irrigation of 452,000 acres in a gross area of 862,549 acres.

Ganges State Tubewell Schemes. This enterprise has enabled the groundwater reservoir underlying the plains of the Western United Provinces at a depth varying from 15' to 45' to be utilised for a widespread system of irrigation. The primary object of the Tubewell System is to provide irrigation facilities in the cultivable tracts of those districts traversed by the Ganges hydro-electric grid, which could not be commanded by canals owing to the limitations of river water. The total number of State tube wells running at the end of the year 1940-41 was 1555, and the total area irrigated was 670,400 acres. The total capital outlay on the State Tubewell Scheme to the end of 1941-42 was 1.69 crores and on the hydro-electric grid 3.73 crores.

Bengal : Improvement of Four National Waterways of the Province

The Scheme aims at maintaining a navigable route throughout the year at all stages of the tide for steamers and boats plying on

(a) the Hooghly and other rivers, including the Sunderbans steamer route,

(b) the Lower Kumar and Bil route,

(c) the Brahmaputra in Bengal, and

(d) the Ganges in Bengal from the Western end to the confluence with the Meghna.

It is estimated to cost Rs. 76,00,000.

Linked with this is another scheme for improvement of sixteen Provincial Waterways.

The Damodar River Flood Control Scheme : This is a very ambitious multipurpose scheme on the model of the Tennessee Valley Scheme in the U.S.A., to provide irrigation, flood control, soil conservation and electric power over a large area. It will take several years to complete it. In the first sessions of the Dominion of India Parliament (November - December, 1947) a Bill was introduced to establish the Damodar Valley Authority, a Statutory Corporation, in which the Central Government and the Provinces of Bihar and Bengal are closely interested.

Dams are proposed to be constructed at several sites on the Damodar river and its tributaries. The resulting reservoirs will serve the purpose of controlling floods and also for storing water for use during the dry season. Part of the flood-water and the whole of the effective storage water are proposed to be utilised for generating power. The increased dry weather discharge is proposed to be used for extending irrigation in the lower reaches of the river. The project will cost Rs. 55 crores.

Mor Reservoir Project :

The areas on the north and south bank of the river Mor are proposed to be irrigated by heading up water in river Mor by constructing a weir at Khatanga.

Irrigation will be effected by distributaries to be fed by two main canals, one for the north bank and the other for the south bank. It is also proposed to make a reservoir by constructing a dam across the Mor river valley at Messanjoie in the Santhal Parganas. This reservoir will supply water during periods of draught in cold weather.

Bihar : Drainage and Irrigation Schemes :

Bihar: It is proposed to carry out 82 drainage and irrigation schemes at a cost of Rs. 172 lakhs in the first five-year period. A vast area of land will be benefited by these drainage and irrigation schemes.

Kosi Project: This is another vast project for multipurpose use of our water resources.

The Kosi Dam Project is designed to provide for flood control, silt control, soil observation, irrigation, drainage, reclamation of water logged area, etc. It will comprise the following component units and connected measures:

(i) A dam, possibly 750 ft. high, across the Chhatra Gorge about a mile and a half above the temple of Barhakshetra.

(ii) Power Plant at the dam to generate 0.93 to 1.4 million kilowatts of cheap firm power depending on the amount of live storage.

(iii) A barrage across the Kosi, some distance below its debouch in the plains.

(iv) One canal taking off from the barrage on the right and one on the left to irrigate the areas.

(v) A barrage across the Kosi near the Nepal-Bihar border.

(vi) Two canals on the left and one canal on the right taking off from the the Bihar Barrage.

(vii) Measures for soil conservation, reclamation of water logged lands, malaria control, etc.

The estimated cost is Rs. 50 crores. The project concerns the Governments of India, Nepal and Bihar between whom negotiations are going on at the moment of writing to establish a joint administrative authority like the Damodar Valley Authority.

Bombay: The Bombay Government have decided to execute 22 irrigation schemes costing in all Rs. 19 crores. The most important of these schemes are the Water Canal Project Kaira District (costing Rs. 105 lakhs and irrigating 75,000 acres ultimately), Girna Project (costing Rs. 4 crores and irrigating 110,000 acres ultimately) and Mula Project (costing Rs. 396 lakhs and irrigating 76,000 acres ultimately). A goodly portion of the existing Irrigation works, particularly in the Deccan is protective; but the projects now planned will add considerably to the productive section also. Multipurpose schemes are also under active consideration to safeguard the Narmada and Taptee Valleys in Gujarat, provide electrical energy, irrigation water, and flood control which is almost an annual phenomenon in this region.

Madras: It is proposed to build a reservoir across the Tungabhadra at Mallapuram near Hospet, with a canal 210 miles long on the right hand side. This is also a multi-purpose scheme for development of Irrigation and Hydro-Electric power. It is hoped that the scheme will be fully executed by 1953.

Pollavaram Reservoir Project. It is proposed to build a reservoir across the Godavari at Pollavaram, and two canals on either side. The capacity of the reservoir will be 500,000 million cubic feet. The scheme will be executed in 15 years. It will be oneof the biggest irrigation schemes in India.

Lower Bhavani Project (Coimbatore District). It is proposed to build a reservoir across the Bhavani and a canal on

the right side 80 miles long. The dam will be a composite one to store about 20,000 million cubic feet.

Gandikotah Reservoir Project (Cuddapah and Nellore Dist). It is proposed to build a reservoir across the Pennar at Gandhi-Kotah gorge to hold about 35 thousand million cubic feet with canals on either side.

Orissa : Mahanadi Project. The multi-purpose development project in the Mahanadi Valley in Orissa consists of three dams across the Mahanadi river; with provision for power generation and for three canal systems for purposes of irrigation. The first dam will be at Hirakud, 9 miles from Sambalpur. The second dam will be located at Tikkerpara some 130 miles down-stream, and the third near Naraj about 10 miles upstream of Cuttack. This scheme will approximately cost Rs. 50 to 70 crores and will also provide navigation facilities.

Punjab: Thal Project. The project consists of withdrawing water for irrigation from the Indus to the extent of 6,000 cusecs. Headworks and main line have partly been completed. The partition of the Province, however, in August 1947, makes the Governments of India and of East Punjab responsible only for the projects in the eastern portion of the Province.

Bhakra Dam Project: It is a multi-purpose project of withdrawing water for irrigation and development of hydro-electric power. It is proposed to construct a 480 feet high dam on the Sutlej at Bhakra with a live storage of 3.4 million acre-feet. The scheme when completed in about 10 years will cost in all about Rs. 42 crores.

United Provinces: Nayar Dam. It is proposed to impound 1.4 million acre feet gross in the valley of the Nayar by building a dam 600 ft. high across the gorge in the river near Marora in Garhwal District, 0.8 million acre feet is expected to be available annually for irrigation draw-off. Primary power to the extent of 30,000 KW. and secondary power amounting to 70,000 K.W. is also proposed to be generated at the dam site. The estimated cost is Rs. 865 lakhs.

Rihand Dam. It is proposed to impound 9 million acre feet gross in the Rihand Basin in Singhrauli Pargana, District Mirzapur, by a 250 ft. high dam across the gorge near Pipri Village. Power will be generated by the artificial head created by the storage dam at a power station situated immediately below it. The capacity of the installed plant is expected to be 150,000 KW. The estimated cost is Rs. 6 crores.

Most of these schemes, it need not be repeated, are multi-purpose projects; and their aggregate capital cost will exceed Rs. 200 crores. As this cost will be spread over several years

the total strain on public borrowing will not be very severe. The benefit to agriculture will aggregate several million acres of land brought under cultivation; and the crop raised thereon may be valued at over 100 crores. The aid to industry from electric power development, and to the public wealth by reclamation of marsh and water-logged land will be almost incalculable. If carefully integrated in a common National Plan, these projects will add very substantially to the natural wealth of this country.

It must be noted, however, that unless side by side with the generation of electrical energy, arrangements are made to develop industries which will utilise this power within the regions served by each of these several Projects, the energy produced may be a waste of labour and capital. Almost every one of these Projects is expected to take several years to complete. During that period, therefore, it ought not to be impossible to prepare and to give effect to plans of industrial developments in these regions which will add substantially to the wealth of the country.

Statement showing major Irrigation works constructed after World War I (Abstract.)

Se. No.	Name of Provinces	Total Capital Outlay (Direct or indirect)	Total area irrigated, Acres (1944-45)
1	Madras ...	7,38,70,540	239,891
2	Bombay ...	5,63,23,776	165,314
3	Bengal ...	2,12,57,928	224,145
4	U. P. ...	12.77,68,525	1,737,473
5	Punjab ...	14,01,40,550	3,144,613
6	C. P. & Berar	3,27,00,384	297,889
7	Sind ...	24,05,58,393	3,275,078
8	N. W. F. P. ...	33,26,523	44,143
9	Baluchistan...	1,10,38,315	124,123
	Total ...	70,69,84,934	9,252,579

@

Detailed Statement showing major works after World War I

Name of Province	Name of Works	Total Capital outlay (direct or indirect)	Percentage on capital outlay	Date when the System first came into operation	Area irrigated in acres 1944-45
1	2	3	4	5	6
		Rs.			
Madras ...	1 Cauvery Mettur System ...	6,47,02,763	1.92	1932-33	1,74,489
	2 Kattalai System ...	41,38,275	3.75	1929-30	35,128
	3 Tungabhadra Project ...	...	...	...	...
	*4 Mopad Reservoir Project ...	24,06,721	1.72	1921-22	6,540
	*5 Toludur Reservoir System ...	26,22,781	4.21	1924-25	23,634
	Total ...	7,38,70,540			2,39,801
Bombay ...	*1 Nira Right Bank Canal ...	4,12,21,453	1.84	1924-25	94,627
	*2 Pravara River Works ...	1,51,02,323	6,06	1926	70,687
	Total ...	5,63,23,776	...	(First came into operation in 1909-10	1,65,314
Bengal ...	1 Midnapur Canal ...	84,92,053	...	...	58,288
	2 Damodar Canal ...	1,27,65,875	2.25	...	1,65,857
	Total ...	2,12,57,928	...	...	2,24,145

@ For the purpose of this Statement major works indicate those costing over Rs. 20 lacs.

Name of Province	Name of Works	Total Capital Outlay (direct or indirect)	Percentage on Capital Outlay	Date when the System first came into operation	Area irrigated in Acres 1944-45
1	2	3	4	5	6
		Rs.			Rs.
U. P. ...	1 Ramganga Canal ...	27,67,141	...	1930-31	24,107
	2 State Tube Wells ...	2,14,87,484	...	1932-33	697,009
	*3 Sarda Canal ...	10,35,13,900	2.74	1928-29	10,16,357
	Total ...	12,77,68,525	...	...	17,37,473
Punjab ...	1 Western Jumna Canal (Extension Scheme) ...	1,35,95,398	...	26- 6-41	86,812
	2 Sutlej Valley Canals ...	8,87,37,607	11.48	1926 27-28	2,003,897
	3 Haveli Canals ...	3,78,07,545	16.84	6/12- 4-39	1,054,904
	*4 Thal Project ...	...	...	...	...
	Total ...	14,01,40,550	...	...	3,144,613
C. P. & Berar ...	*1 Wainganga Canal ...	53,25,748	1.31	August 1916 (completed in March 25)	59,372
	*2 Mahanadi Canal ...	1,58,62,117	1.02	Do	1,97,443
	*3 Kharung ...	58,49,454	1.25	1927-28	79,161
	*4 Maniari ...	56,63,065	0 85	July 1930	61,913
	Total ...	3,27,00,384	...	...	2,97,889

Name of Province	Name of Works	Total Capital Outlay (direct or indirect)	Percentage on Capital Outlay	Date when the System first came in to operation	Area irrigated in Acres 1944-45
1	2	3	4	5	6
		Rs.			Rs.
N. W. F. P. ...	1 Paharpur Canals ...	33,26,523	...	1914 (Date of completion 1917-18)	44,143
Baluchistan ...	1 Lloyd Barrage and Canals Construction ... (Nasirabad Section)	1,10,38,315	1.11	1932-33	124,123
Sind ...	1 United Lloyd Barrage Section ...	23,05,36,753	8.95	1932-33	2,970,543
	*2 Vazirani Canal ...	58,90,634	...	1922-23	174,564
	*3 Baghar Canal ...	20,62,699	...	1922-23	48,168
	*4 Nahiwah ...	20,68,307	...	1901-03 (Completed in 1922-23)	81,803
	Total ...	24,05,58,395	...	...	3,275,078

* Indicates unproductive works.

Large Irrigation Projects in Southern India.

While the Damodar Valley Project, the Kosi River Development, and the Mahanadi Harnessing system may be considered, primarily, to benefit North India, similar schemes are not lacking for the development of the Southern half of the country. The Kauvery has been tapped at more than one place for Irrigation as well as Hydro-electric power supply; and so also has Kistna and Godaveri. The Samgameshwaram project is expected to bring another 25 million acres under cultivation, and is likely to cost Rs. 78 crores when completed. Two dams are to be constructed across the Kistna and the Pennar Rivers in the Kurnool and Nellore Districts of Madras, which will store large volumes of water to be utilised for irrigation of the adjoining lands ; and at the same time permit of generating considerable volumes of hydro-electric energy to serve the industries in the area thus developed. The project is estimated to take 7 years for completion ; and will, when completed, benefit over 25 districts.

SABARMATI IRRIGATION PROJECT *

Yet another considerable project of River Training and multipurpose development is found in the proposal to develop the Sabarmati River in North Gujarat.

The Sabarmati river takes its rise in the Aravalli Hills, and flows from north to south in a considerably deep gorge, finally meeting the Arabian Sea in the gulf of Cambay.

This river drains a considerable area of the southern slopes of the Aravalli Hills ; and though the rainfall in this tract is precarious, it, at times, carries enormous volumes of water to the sea.

The idea of harnessing this river for utilising its water for irrigation was originated first in 1895 when the Bombay Government worked out a project for constructing a reservoir on this river at the same site as is now contemplated, but, after considering both a big and a small reservoir scheme, gave it up as financially unprofitable.

Storage Capacity

The present scheme consists of a storage reservoir of 18,000 m.c. ft. capacity at Dharoi, about twenty miles north-east of Kheralu and forty miles north of Vijapur by a masonry dam, 4,000 ft. long, across the Sabarmati river, a pick-up-weir about twenty-five miles lower down at Ransipur for diverting the river supplies to the irrigation channel, a main canal to distribute the diverted supplies to different irrigation blocks, and storage tanks

* Summarised from the "Times of India" of Thursday, January 8, 1948—Editor.

at the head of the irrigation blocks to store the diverted supplies, with their distributory systems.

The reason for selecting a storage site at Dharoi is that the Sabarmati river flows all along in a deep narrow gorge and no suitable storage site is available within Baroda State territory. At Dharoi, the river passes between the Dharoi and Ambawad Hills with a wide valley upstream and, though the site is not ideal, it is the best available.

As taking out a canal from the reservoir site to the irrigated areas situated several miles below in a very difficult country, especially near Hadol where the hills almost hug the right margin of the river, was considered extremely costly and difficult, it is proposed to let down the water from the reservoir into the river itself and pick it up again at a pick-up-weir to be constructed at Ransipur in Vijapur Taluka and take out a canal therefrom. Here too, as the river runs in a deep gorge, the pick-up-weir also becomes a costly structure. Also the left flank of the weir as well as its surplus works have to be in the Idar State limits.

Two Alternatives

As the Dharoi reservoir is situated in foreign limits, and as the question of participation with the Bombay Government in the project was uncertain, the project is developed under two alternatives, one with Dharoi reservoir and the other without it. In the latter case, the monsoon floods could be diverted and stored in five intermediate storage tanks of an aggregate capacity of about 5,000 m. c. ft. and thereafter utilised for irrigation of *Kharif* and *Rabi* crops.

This alternative was proposed to be the first stage of the project under which about 6,000 bighas of perennial crops like sugarcane would be irrigated in Vijapur Taluka, and 56,000 bighas of other seasonal crops in Vijapur, Visnagar, Kadi and Kalol Talukas from five storage tanks situated at Kada, Dharusan, Anandpur and Indrada. The second stage was to be Dharoi reservoir if and when Bombay Government decided to participate in the project. In this case there would be further irrigation to the extent of 16,000 bighas in Baroda State and 30,000 bighas in Bombay Province.

Thus the project as proposed has the potentialities of irrigating, in all, about 125,000 bighas which will mean an increase in the food grain production of about 50,000 tons.

Besides irrigation, the project would also provide facilities for generating electric power to the extent of 3,000 to 6,000 KW which could be utilised for electric pumping or other development works. Though the cost of the electrical side is not included in the project estimates, provision has been made for the

necessary pipe sluices in the dam which could later be utilised for that purpose.

Municipal Objection

An objection was raised to the scheme by the Ahmedabad Municipality on the plea that the water supply of the Ahmedabad city drawn from the Sabarmati river will be adversely affected by the scheme. To overcome this objection it was agreed by Baroda in a meeting between the Chief Engineer, Baroda, and Superintending Engineer, Northern Circle, Bombay, that Baroda will guarantee the average monthly discharge obtaining in the river based on the gauging of the river and make good the deficiency by letting down water from the storage upstream and to that end joint gauging stations are opened at Hadol, Ransipur and Dudheswar (Ahmedabad) and data are being collected for the last three years.

The Bombay Government have expressed their willingness to participate in the project provided the Central Waterways, Irrigation and Navigation Commission pronounces it to be technically feasible. The Ahmedabad Municipality is also amenable to accept the guarantee of the customary flow, provided Bombay Government also implements this guarantee. The whole project has been submitted to the Central Waterways Commission of the Government of India for technical scrutiny.

Scope Of The Project

The conference has tentatively come to a conclusion that, since the Bombay Province and the Idar State have both expressed their willingness to participate, the scope of the project should be extended to meet as much demand as possible and hence the capacity of the reservoir should be increased to the maximum possible. They have also suggested that the project should provide not only irrigation, but should be a multi-purpose scheme catering for irrigation, power generation, flood control, afforestation and fish culture, and to this end the whole valley should be investigated on a unified basis.

It was suggested that in view of the different jurisdictions in the project area, it was desirable that this further investigation should be taken up by the Central Waterways organisation and some experienced staff for the purpose should be placed at their disposal by Baroda. A final decision in the matter will be shortly taken and the question could then be further dealt with.

Costs

The project, as formulated by Baroda, was estimated to cost at pre-war rates Rs. 1.64 crores including Dharoi reservoir and was expected to yield about 4¼ per cent. But in view of the

considerable increase in rates as well as the greater scope of the project now proposed by the Central Waterways Commission, it is very likely that it would cost Rs. 5 crores approximately. Baroda's share as was previously assumed might roughly be taken as about 60 per cent. of the total both in the cost as well as in the irrigation supplies, and at that rate Baroda's share might come to about Rs. 3 crores.

The advantage of the project, apart from direct revenue, will be manifold. Over and above irrigating about 200,000 bighas in Baroda, Idar and Ahmedabad territories, it will generate about 6,000 KW of electric power, reduce the floods in the river considerably, provide afforestation and soil stabilisation in the catchments which will improve the meteorological conditions, provide extra food in the form of fish and raise the subsoil level of water in the surrounding area.

DAMODAR VALLEY AUTHORITY

Among the most considerable of the multi-purpose River-Training and Water-Utilisation Schemes that form the outstanding items in the programme of national development undertaken by the first popular and responsible Government of India is the control and exploitation of the Damodar River and its tributaries. More than one Province, and the Country as a whole, are concerned in the scientific operation and control of this vast project. Statutory Authority, with definite powers and functions, are needed to carry this immense undertaking to fruition. A great public utility enterprise, public control, and regulation by the Central Government are the *sine qua non* for the effective working and management of this great task of national reconstruction.

The Damodar River rises in Western Bihar ; and flows generally in a south-westerly direction into Bengal. It is not a perennial stream, like the great rivers of the Gangetic or the Indus Valley. Its waters grow in volume with the rains, which have so far not only run to waste, but often caused serious damage to life and property through uncontrolled floods. The project now undertaken by Government will bund the river, and preserve its periodical increase in waters to form reservoirs, which can then be utilised for irrigating the adjoining lands. Dams will be built across the river to generate hydro-electric power, which is expected to help substantially the new industries that will be set up in the neighbourhood. Lands reclaimed from river swamps will be cleared of malaria and such other perils to healthy life of the people inhabiting those parts ; while scientific cultivation on an industrialised scale, with mechanical aids of the modern type, would be easy to adopt for increasing substantially the yield per unit of cultivation.

For the effective attainment of these objectives, the Bill, now before the Indian Legislature, seeks to establish a Statutory monopolistic Corporation, called the Damodar Valley Authority, on the model of the Tennessee Valley Authority in the United States, whose limits of jurisdiction will be fixed by the Central Government. It is to be an autonomous Authority, consisting of a Chairman and two other members, appointed by the Central Government after consultation with the Provincial Governments concerned. Every member of the Corporation is a wholetime officer of the Corporation, receiving such remuneration and having other conditions of service as may be prescribed.

The principal Officers and Servants of the Corporation are:—

1. The Secretary who will be the chief executive officer, appointed by the Central Government.

2. Treasurer, appointed by the Corporation, with the previous approval of the Central Government, and charged with the financial side of the Corporation's work.

3. Such other officers and servants appointed by the Corporation as it considers necessary for the efficient performance of its functions.

Conditions of Service of Officers and Servants. The pay and other conditions of service of the Secretary and Treasurer, will be prescribed by Government ; and for other officers and servants determined by regulations.

General disqualification of all officers and servants. No person directly or indirectly, having any share or interest in any contract by or for the Corporation, or any employment under the Corporation otherwise than as its officer or servant, can be or remain such officer or servant.

A share, however, in a company contracting with or employed by Corporation is not a disqualification.

The Corporation may from time to time appoint one or more Advisory Committees for securing proper and efficient discharge of its functions.

The Corporation will promote, by appropriate measures, the agricultural, industrial, economic and public health development of the area within its operation. Such measures may include schemes for

(a) promotion and operation of irrigation and water supply works ;

(b) generation, transmission and distribution of electrical energy, both hydro-electric and thermal ;

(c) control of flood in the Damodar and its tributaries, and for improvement of flow conditions in the Hooghly ;

(d) the promotion of navigation in the Damodar and its tributaries ;

(e) the promotion of afforestation and control of soil erosion in the Damodar Valley.

Irrigation & Water-Supply.

With the approval of the Provincial Government concerned, the Corporation may construct canals and distributaries and maintain and operate them. The Provincial Government concerned may, however, after reasonable notice and subject to fair compensation, take over the maintenance and operation of any such canal or distributary. After consultation with the Provincial Government concerned, the Corporation may levy rates for the bulk supply of water to that Government for irrigation, and fix the minimum water which shall be made available for such purpose.

The rates at which such water is supplied by the Provincial Government to the cultivators and other consumers will be fixed by that Government after consultation with the Corporation.

Free Supply of Water to Those Whose Supply Has Been Stopped or Reduced

If to operate its schemes, the Corporation stops or reduces the water supply of any person who had prescriptive right to such water for agricultural, industrial or domestic purposes it shall arrange to make good such supply of water free of cost.

No person shall construct, operate or maintain in the Damodar Valley any dam or installation for the extraction of water, unless the plans for such construction, operation or maintenance have been submitted to and approved by the Corporation.

The Corporation will have exclusive right to sell electrical energy to any consumer in the Damodar Valley, including a Provincial Government, provided the energy is taken by the consumer at a pressure of 30,000 volts or more. The limits of the Corporation operations may be extended with the consent of the Government concerned. Except with the permission of the Corporation, no one else can transmit electrical energy in the Damodar Valley at a pressure of 30,000 volts or more. By agreement with the Provincial Government concerned, the Corporation may sell electrical energy to any consumer in the Damodar Valley requiring the supply at a pressure lower than 30,000 volts. The latter cannot, without the consent of the Corporation, generate or allow any person to generate any electrical energy at an installation having an aggregate capacity of more than 10,000 kilowatts in any part of the Damodar Valley.

Effect on existing licences. Existing licences becoming inoperative because of the working of the new authority, shall be deemed to be revoked or modified on condition that the Corporation purchase the undertaking of the licensee ; and if it is modified the Corporation either purchases the undertaking or pays fair compensation to the licensee at his option.

The purchase price or the amount of compensation payable must either be agreed to between the parties or be determined by arbitration.

The schedule of charges for the supply of electrical energy, including the rates for bulk supply and retail distribution, is fixed by the Corporation including the terms and conditions of distribution and retail sale.

Besides these principal activities, the Corporation may establish, maintain and operate laboratories, experimental and research stations and farms for conducting research for

(a) utilising the water, electrical energy, and other products most economically and the maximum development of the Valley,

(b) determining the effect of its operations on the flow conditions in the Hooghly,

(c) making improvements in navigation conditions in Calcutta, and

(d) carrying out any other function specified in the Act.

Powers.—The Corporation has power, *inter alia,* to do everything necessary or expedient for the purposes of carrying out its functions. In particular, it can

1. acquire and hold leases, sell or dispose of such movable and immovable property as is necessary,
2. construct all necessary dams, barrages, reservoirs, power houses, transmission lines and substations, navigation works, irrigation and drainage canals etc.
3. prevent pollution of any water under its control, and withhold any water from any person who discharges into such water deleterious effluents,
4. stock its reservoirs or water courses with fish and regulate fishing,
5. undertake resettlement of the population displaced by the dams, land acquisition for reservoirs, and protection of watersheds,
6. aid in establishing co-operative societies for the better use of the new facilities,
7. undertake measures for the prevention of malaria.

Power to close roads and open spaces. After giving due notice to those concerned the Corporation may

(a) turn, divert or discontinue the public use of any road, or open space vested in it subject to paying due compensation.

(b) it may carry out all or any of the functions and exercise all or any of the powers of a Provincial Government in the Damodar Valley, as provided for in this Act.

Co-operation and Avoidance of Submersion

The Corporation must co-operate with the participating Governments, railway authorities and local bodies in all measures they take to minimise the inconvenience and discomfort to

the population affected and likely to be caused by the submersion of lands, roads and communications. It must bear the cost of any realignment of roads necessitated by such submersion.

Special care must be taken in dealing with merged lands belonging to any particular community or religious sect, graveyards and places of religious worship. The Corporation must bear the cost of resettlement of the people affected.

Every endeavour must be made to avoid submersion of coal or mineral deposits, in cooperation with the coal mining industry and other bodies concerned, including participating Provinces.

Finance, Accounts and Audit.

All expendture incurred by the Central Government for establishing the Corporation, will be treated as capital charge, which will be adjusted between the participating Governments in accordance with the provisions of the Act.

Property and Funds.

All property acquired and works constructed for the purposes of the Damodar Valley Scheme before the establishment of the Corporation vest in the Corporation ; all income derived and expenses incurred will be accunted for in the Corporation Books.

All receipts of the Corporation will be credited to its own Fund and deposited in the Reserve Bank, or the Imperial Bank and all payments made therefrom.

Capital Liability of Participating Governments.

The participating Governments will have to provide the entire capital required by the Corporation to complete any project undertaken by it in stated proportions. The total capital expenditure chargeable to a project including overhead costs must be distributed between Irrigation, Power, and Flood Control.

Capital for Irrigation.

The total amount of capital allocated to Irrigation is to be shared between the two Provincial Governments in proportion to such works constructed exclusively in its jurisdiction ; and the cost incurred for projects common to both the Provinces must be shared in the proportion of the guaranteed annual off-take of water for agricultural purposes by either.

Capital for Power

The total amount of capital allocated to Power is to be shared equally between the three participating Governments ; while that for Flood Control, up to Rs. 14 crores must be shared equally

between the Central and the West Bengal Government. Any amount in excess of Rs. 14 crores must be paid only by West Bengal.

Disposal of Profits and Deficits.

Subject to the provisions of the Act the net profit, if any, derived from either Irrigation, Power or Flood Control, must be credited to the participating Governments in proportion of the total capital contribution on each. The net deficit on account of any of the objects must be made good by the Governments concerned on the same basis except that the deficit on flood control must be made good entirely by the Provincial Government of West Bengal only.

Payment of Interest.

The Corporation shall pay interest on the amount of capital provided by each participating Government at such rate as may, from time to time, be fixed by the Central Government.

Interest Charge and other Expenses.

The Interest charge and other expenses are to be added to the capital cost so long as the Corporation accounts show a deficit. All receipts must be utilised to reduce capital cost.

Provision for Depreciation and Reserve.

The Corporation must make provision for depreciation and reserve and other funds at rates and on terms specified by the Auditor-General of India. Net profit of the Corporation will be determined only after this provision has been made.

Corporation's Share in Provincial Betterment Levy

If a Provincial Government imposes any Betterment Levy, the Corporation must be allowed a share in proportion to its operations having brought about such betterment.

Borrowing Powers.

The Corporation may, with the approval of the Central Government, borrow in the open market for carrying out its functions under this Act.

Exemption of the Corporation from Central Taxation.

Notwithstanding anything in any other law the Provincial Governments and the Corporation will be exempt from income tax, corporation tax, or any other like tax levied by the Central Government.

Annual Budget and Report.

The Corporation must, in October each year, prepare in the prescribed form a budget for the next financial year showing its

estimated receipts and expenditure, and the amounts required from each of the three participating Governments during that period. These Governments must be supplied printed copies of the budget, by the 15th of November.

It must likewise prepare, in the prescribed form an annual report within six months after the end of the financial year, giving full account of its activities during the previous financial year, with particular reference to :—

(i) irrigation ;
(ii) water supply ;
(iii) electrical energy ;
(iv) flood control ;
(v) navigation ;
(vi) afforestation ;
(vii) use of lands ;
(ix) resettlement of displaced population ;
(x) sanitation and public health measures ;
(xi) economic and social welfare of the people in the area of operations ;
(xii) Year's income and expenditure including the amounts attributable to each of the three main objects ; and distribution of the capital cost between the three participating Governments, giving progressive totals from the inception of the Corporation and up-to-date financial results. Copies of the Report must be supplied to the participating Governments.

The accounts of the Corporation must be maintained and audited as prescribed.

Miscellaneous.

The Central Government may issue such instructions on matters of policy to the Corporation from time to time as it thinks proper and the latter must obey those instructions.

If any dispute arises between the Central Government and the Corporation as to whether a question is or is not a question of policy, the decision of the Central Government shall be final. If any dispute arises between the Corporation and any participating Government regarding any other matter it must be referred to an arbitrator appointed by the Chief Justice of India, whose decision shall be final and binding on all concerned.

Compulsory Acquisition of Land for the Corporation.

Any land required for carrying out the functions of the Corporation under this Act shall be acquired for the Corporation

as needed for a public purpose under the Land Acquisition Act 1894.

Power to make Regulations

The Corporation is empowered to make regulations for carrying out its functions under this Act, regarding :—

(a) making appointments and promotions of its officers ;
(b) specifying its officers' and servants' conditions of service ;
(c) laying down the functions and duties of the Treasurer ;
(d) prescribing the manner in which water rates and electrical energy charges are to be recovered ;
(e) preventing the pollution of water under its control ;
(f) fishing from such water ;
(g) procedure governing its business ;
(h) prescribing punishment for breach of any regulation ;

All such regulations must, as soon as possible, be published in the official Gazettes.

ELECTRICITY

Rationalisation of the Production and Distribution.

Another piece of constructive legislation, introduced in the Autumn (1947) Sessions of the Indian Constituent Assembly (Legislative), concerns the production and distribution of Electric energy in the country. The Bill seeks to establish a Grid system all over the country. For this purpose national legislation, instead of Provincial, is necessary, though the units will be more directly interested. It is hoped the measure would help to rationalise both production and distribution of electric energy ; and thereby assist materially in the industrial development of the country.

Electric energy, particularly that produced by hydro-electric works, is bound to enjoy a most vital place in the economy of a country, which, in proportion to its size, population and industrial possibilities, is markedly deficient in good quality coal or petrol. Electricity is the most efficient and economic substitute for coal either as fuel or source of energy-power. The potential supply of Hydro-electric energy in this country is immense. At the moment, however, hardly 2% of that potentiality has been developed and hence the need for some machinery for an intensive development of his power.

The proposed legislation will help Provincial Governments, local bodies, as well as private Corporations holding License for the production or distribution of electrical energy, to organise

and rationalise the generation and consumption of this indispensable means of operating modern industrial machinery, so as to minimise,—not eliminate altogether,—the room for private profit from this great source of public utility. We have a limited supply of organising enterprise, administrative experience and technical knowledge. To mobilise all these for effective employment in public service, and to eliminate needless internecine competition, public control, regulation and supervision,—if not public ownership and management,—are introduced from the start so that the programme may be carried out in the shortest time, and to the greatest advantage to the country.

As a first step towards attaining this aim, the Bill seeks to establish *Provincial Electricity Boards,* each a corporate organisation in itself with statutory powers and functions. A Board may consist of from 4 to 7 members. Three of these nominees of the Provincial Government shall be full time members of the Board, paid such salaries as may be prescribed, and form the Standing Committee or the Chief Executive Authority of the Board. One of these three must be a qualified Engineer, experienced in administrative and business matters; and he shall be Chairman of the Board, holding office for seven years. Another must be an Electrical Engineer, and the third an Accountant. These latter two are to hold office for five years, while the remaining or part-time members, also appointed by the Provincial Government, will hold office for three years. In appointing them, the Provincial Government must consult the Provincial Organisations representing commerce and industry, agriculture and labour, engineering profession and Local Self-Governing bodies. Members of the Local or Central Legislature, or those having any direct or indirect interest in any contract with the Board, will be disqualified from membership. Full-time Members must have no interest in any company in any way concerned with electric production or supply, or manufacture of any plant or machinery needed for the same. If any of them hold any shares etc. in such concerns, the same must be disposed of within three months of the appointment, so that there will be no trace of personal interest left.

Two or more Provinces or States may combine to have a common Board by specific agreement, which must lay down the financial contribution or interest of each, and arrangements for consultations in matters of common interest coming under the Board's jurisdiction. Regional Advisory Committees may be constituted to advise the Board on such matters as the Provincial Government may lay down in the notification establishing such Committees.

The powers and duties of Provincial Electricity Boards have been laid out elaborately in several sections of the proposed

legislation. Under the law the Board is charged with promoting efficient, economic and coordinated development of the supply of electricity within the Province, especially in areas not served by any licensee. In particular, the Board is required :—

(a) to prepare and carry out, when sanctioned, schemes of electric development ;

(b) to supply electricity to owners of controlled stations, and to licensees whose stations are closed down ;

(c) to supply electricity as soon as practicable to any other licensees if the Board is entitled to do so.

It may supply electricity to any licensee in any area in which a sanctioned scheme is in force. But it cannot supply electricity for any purpose directly to any licensee for use in any part of the area of supply of a bulk-licensee without the consent of the latter, unless the bulk-licensee is unable or unwilling to supply ; or for any purpose to any other person for use in any part of the area of supply of a licensee without the consent of the licensee, unless the licensee himself is unable or unwilling to supply.

If the Board declares its intention to supply electricity for any purpose in any area it is competent to supply ; no licensee can, without the consent of the Board, supply electricity for that purpose in that area.

Power to Board to engage in Certain Undertakings. The Board may manufacture, purchase, sell or let on hire any electric fittings, wires or apparatus for lighting, heating or motive power, for any industrial or agricultural machinery, and may install, connect, repair, maintain for adequate consideration fittings, wires, apparatus or machinery needed for the same.

It may also maintain shops and showrooms for the display, sale or hire of fittings, wires, apparatus and machinery and give demonstrations of their working or hold exhibitions.

It may, with the previous approval of the Provincial Government, take appropriate measures to advance the development of water-power in the Province, and make hydrometric surveys for the purpose.

At its own expense the Board may conduct any investigations or experiments it thinks fit for improving transmission, distribution and supply of electricity, and for that purpose establish and maintain laboratories to test and standardise electrical instruments and equipment. It may appoint such consulting engineers as it thinks fit.

To give effect to these powers and duties the Board will have all the powers and obligations of a licensee under the Indian

Electricity Act, 1910, for the whole Province in addition to the powers granted under the proposed legislation.

The Board's Works and Trading Procedure.

Preparation of Schemes. With a view to rationalise the production and supply of electricity in any area, the Board may prepare schemes, providing for :—

(a) establishment of the Board's own generating stations :

(b) the designation of existing or new stations as "controlled stations", at which electricity is generated for the Board ;

(c) the interconnection, by main transmission lines constructed newly or acquired by the Board, of any generating stations with others, or with Licensee's stations ; in the same or in any other area in which the Board operates.

No such scheme can, without the consent of the owner, designate as a "controlled station" any generating station belonging to a non-licensee ; authorise use or acquisition of a main or other transmission line belonging to a non-licensee.

Every scheme prepared by the Board must be duly published. The Board must notify the date, not less than two months after the notice, by which all interested persons may put forward their point of view on such a scheme.

After considering these representations, and making necessary inquiries, the Board may sanction the scheme as it stands or with such modifications as it thinks fit, generally or for part of the area specified.

But no scheme can be sanctioned by the Board, the capital expenditure on which exceeds Rs. 25 lakhs without prior consultation with the Central Technical Power Board. Any recommendations that Board makes, as required under the law, must be duly considered by the Board.

And if the Central Technical Power Board wants any further information on such a scheme, the Board must supply it within a month of the request.

The Central Technical Power Board must, before making any recommendations about a scheme estimated to cost more than Rs. 25 lakhs, consider whether or not :—

(a) any river-works proposed by the Board will prejudice the prospects for the fullest development, of the river or its tributaries for power—having full regard to the requirements of irrigation, navigation and flood-control, and the best location of any proposed dam ;

(b) the scheme will prejudice the proper combination of hydro-electric and therto-electric power necessary to secure the greatest possible economic output of electric power ;

(c) the proposed main transmission lines will be reasonably suitable for regional requirements ;

(d) the estimates of prospective supplies of electricity and revenue therefrom are reasonable.

Recommendations of Central Technical Power Board.

The Central Technical Power Board, when consulted, on any scheme, must forward its recommendations thereon to the Board, and a copy to the Provincial Government, within six months from the date of receiving the scheme. This period must be increased, if the Board takes longer time to supply any information asked for by the Power Board. Every sanctioned scheme shall be carried out.

Power to Alter or Extend Schemes

The Board may from time to time alter or extend a scheme by a supplementary scheme duty sanctioned. Minor alterations would not need formal sanction.

Where a generating station situated within an area for which a scheme is in force, is styled in the scheme a "controlled station", the relations between the Board and the licensee owning the station must be regulated by the provisions of the First Schedule to the proposed law.

Supply by the Board to Licensees Owning Generating Stations.

The Board may at any time declare to a licensee owning a non-controlled generating station in an area for which a scheme is in force, that it can supply electricity to the licensee for the purposes of his undertaking, and the licensee must accept it as provided for in Schedule II.

Power to Close Down Generating Stations

The Board may at any time declare to a Licensee owning a generating station situated in the area for which a scheme is in force, that the station shall be permanently closed down, and in that case, if the station is a controlled station the provisions of Part III of the First Schedule, and in other cases those of the Third Schedule will apply to the relations between the Board and the licensee, with reference to the station to be closed down.

Power to Purchase Generating Stations or Main Transmission Lines.

If under the First or third Schedule the Board desires to purchase a generating station or its sanctioned scheme provides for

the purchase of a main transmission line of any licensee, either of these will vest in the Board free from any debt, mortgage, lien, or other similar obligation of the licensee, except as provided for in the law ; and for this the Board must pay the price as determined according to the Fourth Schedule as soon as the amount is fixed, including interest on that amount from the date of purchase to the date of payment, at 1% over the average Reserve Bank Rate.

If the generating station or main transmission line purchased is under construction, extension, or repair, at the date of purchase, the rights and liabilities of the former owner under any contract for such construction etc. will be transferred to the Board.

If any generating station purchased by the Board contains any plant or apparatus which was previously used for the purposes of generation as well as transmission or distribution, or the latter purpose only, such plant or apparatus will not be purchased, but will remain the property of the licensee, unless otherwise agreed upon.

Provision of New Generating Stations.

The Board may itself establish a new generating station or make suitable arrangement with a Licensee in any area in which it is required by any sanctioned scheme to be situated. Where a new generating station is established or acquired by the Board,—not for closing down,—it may operate the station itself or make arrangements with any licensee to do so.

Where the Board has purchased a main transmission line and by using it necessitates alteration or replacement of switch-gear or other apparatus of any licensee, the Board must defray all reasonable expenses incurred by the licensees in effecting such alteration or replacement. Any dispute as to whether such alteration or replacement was necessary, or the expenses incurred for the same reason, must be settled as provided for in section 74, unless otherwise agreed upon.

Use by Board of Transmission Lines.

If in any case the Board wants to use any main or ordinary transmission lines of a licensee, it can do so upto its surplus capacity above the requirements of the licensee.

The Board may, by agreement with the parties concerned, use any other main or ordinary transmission line for such time and upon such terms as may be agreed.

Powers to Board for Placing Wires, Poles, etc.

The Board has power to place any wires, poles, wall-brackets, etc. for the transmission and distribution of electricity, tele-

graphs, telephones necessary for the proper coordination of the Board's works if provision is made to that effect in the sanctioned scheme.

Power to arrange for purchase or sale of electricity.

The Board may arrange, to purchase electricity with any person on such terms as may be agreed upon, up to the surplus produced by such person. Similarly the Board may, arrange with any Government or person to purchase or sell electricity to be generated or used outside the Province on any terms that may be agreed upon, subject to the consent of the Provincial Government concerned.

Restrictions on Establishing New Generating Stations

No licensee, or other person, not being a Federal Railway can establish or acquire, without the previous written consent of the Board, a new generating station, or extend or replace any major unit of plant or works pertaining to the generation of electricity. Consent must not be unreasonably withheld, unless the Board gives to the applicant being a licensee, an undertaking that it is competent to, and will, within eighteen months from the date of the application, afford to him electric supply equal to that required by him under his application, or shows to the applicant sufficient reasons to believe that the electricity required by him could be more economically obtained within a reasonable time from another source. Similar provisions apply for consent to the extension or replacement of any major unit of plant or works engaged in generating electricity. The applicant must give full particulars about the station, plant, etc. as the Board may require.

Power to Board to Enter Upon and Shut Down Generating Stations

If any licensee fails to close down his generating stations following the required declaration of the Board or if any person establishes or acquires a new generating station, or extends or replaces any plant or works in any generating station, in contravention of the law, the Board may authorise any of its officers to enter upon the premises of such station and shut down the station, the plant or works.

Any expenses incurred by the Board on this account shall be recoverable from the person concerned as an arrear of land revenue.

The Grid Tariff.

The Board must fix by regulation the Grid Tariff, from time to time, for each area where a scheme is in force ; the tariffs for the several areas may be different. This Tariff will apply to

such sales to licensees where so required under any Schedules, and also to the sales to licensees in other cases, unless the Board thinks that the transmission expenses in providing the supply would be unreasonably high because of the magnitude of the supply required. In that case the Board may charge higher rates.

The Grid Tariff may contain provisions for :—

(a) adjustment of price having regard to the supply taken, the cost of fuel or both ;

(b) a minimum charge related to a past or prospective demand of a licensee.

The Board may include Grid Tariff, other terms and conditions, not inconsistent with the law or regulations.

Power to make Alternative Arrangements with Licensee.

The Board may make arrangements mutually agreed with any licensee within the Board's area for the sale of electricity and its price, or purchase, operation, or control of any generating station or main transmission line, provided that in making such arrangement, the Board must not show undue preference to any licensee.

Licensee's Power to Carry out Arrangements.

Where the Board is authorised, or required, to enter into arrangements with any licensee for any purpose, the licensee would be entitled to enter into and carry out any such arrangements.

Sale of Electricity to Non-Licensees.

The Board may supply electricity to any person not being a licensee upon such terms and conditions as it may fix, having regard to the nature and geographical position of the supply and the purpose for which it is reqiured provided that no undue preference will be shown to any person by the Board.

Circumstances Under Which Board May Not Supply Electricity.

In cases where it is not permissible for the Board to supply electricity directly to a licensee, owning a generating station, the Board is not permitted to supply electricity directly to any licensee or person to whom it is not otherwise entitled so to supply electricity.

The Board and any licensee shall at all times have a right of access to their own property on, in, over and under the property of the other.

Board's Power to Connect Meters etc. of Licensee.

The Board may connect with the apparatus of any licensee any such correct meters, switch-gear and other equipment as may be necessary to carry out the law's provisions.

Every licensee owning a generating station must comply with all reasonable directions from the Board to achieve maximum economy and efficiency in working his station.

Leases of Generating Stations

No licensee can lease out his generating Station without the previous approval in writing of the Board, who may impose any conditions while granting its approval.

If any lease is outstanding on the day the Board notifies, licensee must submit the terms of the lease for the approval of the Board.

Licensees' charges to consumers:

The licensee's charges, unless it is a local authority, are to be those laid down in Schedule VI and Table attached to Schedule VII. From the commencement of the next year of account of the Licensee consequential changes regarding payment of the Board's dues, Lower Limit of the Power Supply, Right of Way etc. shall come into operation as laid down in the law.

(a) The Board may itself, or when requested so to do by the licensee, constitute a Rating Committee to examine the licensee's charges for the supply of electricity, and to make recommendations thereon to the Provincial Government. But no Rating Committee need be constituted in respect of a licensee within three years from the date on which such a committee has reported about that licensee, unless the Provincial Government declares that circumstances have arisen rendering the orders passed on the recommendations of the previous Rating Committee unfair to the Licensee, or his consumers.

(b) Such a Rating Committee consists of two members of the Board, one to be Chairman, and one experienced in accounting and finance. A third, representing Licensees Association must be co-opted. If there is no such association, the co-opted member must be chosen from a commercial organisation.

(c) The Rating Committee after giving reasonable opportunity to the Licensee to be heard, report to the Provincial Government recommending charges for electricity which the licensee may make to any class of consumers.

The Committee, however, cannot recommend alteration in a licensee's charges which would prevent him from earning clear profits sufficient to afford him a reasonable return during the next three years.

(d) Within one month after the receipt of the report under clause (c) the Provincial Government shall cause the report to be published in the official Gazette, and may at the same time make an order in accordance therewith fixing the licensee's charges for the supply of electricity with effect from such date, not earlier than two months or later than three months after the date of publication of the report, as may be specified in the other; and the licensee shall forthwith give effect to such order :

Provided that nothing in this clause shall be deemed to prevent a licensee from reducing at any time any charges so fixed.

Power to direct Amortisation and Tariffs Policies of Licensees being Local Authorities.

The Board may direct the amortisation and tariffs policies of a local authority, licensee with respect to the licensed undertaking in such manner as the Board after hearing the Local Authority considers expedient, and such licensee must give effect to any such directions.

The Board's Finance, Accounts and Audit.

As a general principle the operations of the Board must not be carried out at a loss as far as practicable and after taking credit for Provincial Government subvention, if any be allowed. The charges must be adjusted accordingly from time to time. The Board, however, is authorised, when necessary, to meet its operating, maintenance and management expenses out of capital, and other expenses allowed under the law, if sanctioned by the Provincial Government.

The debts and obligations as well as contracts made by the Provincial Government, for any purpose under this law before the Board comes into existence must be taken over by the Board as its own obligations. The same principle applies to dues of the Provincial Government, as well as legal proceedings by or against it.

All expenditure which the Provincial Government declares to have been incurred before the Board comes into existence on capital account in this connection, must likewise be taken over, as loan to it, by the Board.

Annual Financial Statement

In February of each year the Board must submit to the Provincial Government a statement in the prescribed form of its estimated capital and revenue receipts and expenditure for the

ensuing year. This statement must include a statement of the salaries of members, officers and servants of the Board and such other particulars as may be prescribed.

The Provincial Government, as soon as possible, after the receipt of the said statement lay it before the local Legislature, which may discuss, but not vote upon it. The Board must give full consideration to the comments made in the Provincial Legislature, though not bound to defer any expenditure which it considers urgent pending receipt of those comments.

The Board is also empowered at any time during the year to submit a supplementary statement, to the Provincial Government ; and the same rules will apply to that statement also.

Restriction on Unbudgeted Expenditure

The Board cannot expend any sum exceeding Rs. 10,000|- as recurring expenditure, or more than Rs. 50,000|- as non-recurring expenditure, unless such sum was included in the financial statement submitted to Government, except under extremely urgent circumstances. Under those circumstances the Board must submit a report to the Provincial Government showing the source from which it is proposed to meet the expenditure.

Taken as a whole, the proposed legislation is open to criticism from several angles, which, it is to be hoped, will be obviated by its amendment in the Select Committee to which it is referred. It is not a clear-cut proposal for complete public ownership and control of electrical undertakings in a Province or State, but recognises the existence of private generators or distributors. It permits the Provincial Board to work with existing Licensee in its area, or take over the latter's undertaking, fix the charges, control and use its station, transmission lines, wires and other apparatus as its own. In its own undertakings, the Board is not to operate them strictly for public benefit, if it be unavoidable in the process to incur a loss. But the Provincial Government concerned may make subventions, in which case a commercial surplus of revenue over expenditure would be unnecessary. The details of the constitution of the Board, of its powers and duties, and its relations with corresponding other authorities may also need to be amended. On the whole, however, it may be regarded as a fairly comprehensive beginning, a welcome step forward, calculated to intensify the generation and use of electrical energy in power-driven machinery which would increase the volume of production in the country.

Printed by A. P. Sata, at the States People Press, Fort, Bombay, and Published by M. K. Vora for Vora & Co., Publishers Ltd., Round Building, Kalbadevi Road, Bombay 2.